TRIUNFO DO XINGU GROUPED REDD+ PROJECT

Document Prepared by Systemica Ltda.

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1.1 Summary Description of the Project

The world has a forest area of 4.06 billion hectares (ha), which is 31% of the total land area. More than half (54%) of the world's forests are in just five countries and Brazil is in second place among nations with the most forest area worldwide, having in its territory 12% of the global forest area (UNEP, 2020). On the other hand, Brazil is one of the countries with the highest rates of forest loss (Tyukavina et al., 2017).

According to data of 2022 from the *Instituto Nacional de Pesquisas Espaciais* (INPE, 2022a), 72.978 million of hectares of the Amazon Biome area were deforested until 2020. Currently, 17% of the original forest has already been deforested. Among the regions that suffer the most from deforestation are the following states Pará (34.5%), Mato Grosso (32.3%), and Rondônia (13.8%). Among the municipalities in Brazil with the biggest deforested accumulated area, Altamira is in the third position with 1.113 million of deforested hectares.

The Triunfo do Xingu Grouped REDD+ Project (hereinafter also referred to as “TdX”) is composed of seven private rural properties located in the Municipality of Altamira, in the south region of the State of Pará. Six of them are owned by Rafael Sefer, the seventh one is owned by Didácio Barros. According to the geo-referencing data, the total area of the project is established at 10,636.02 ha. This project will be eligible under the Reducing Emissions from Deforestation and Forest Degradation (REDD) category, using the VM0015 methodology for avoiding unplanned deforestation (AUD) (VERRA, 2012a). It also aims to be registered under the Verified Carbon Standard (VCS) combating the decreased carbon stock in the Brazilian Legal Amazon.

The crediting period of the project is 30 years. The start date is on August 31, 2022, and therefore the crediting period is expected to end on August 30, 2052. The baseline scenario developed classifies the land area between forest and non-forest, considering in the first category only areas with more than 10 years of forests before the project start date. Only those forest areas with more than 10 years were considered in the project area. The baseline is going to be used for the first six years of the project, since these six years are the maximum period until a baseline scenario reassessment needs to be done, according to VCS requirements. All the analysis were executed with a conservative approach, keeping the project consistent.

The TdX will accomplish its environmental benefits through a successful monitoring system by assessing satellite images and using them for remote geospatial analysis. It will also generate economic benefits through investments in local communities, teaching them sustainable ways to maintain their economic activities improving social environment quality.

To execute the installation of this project and to achieve its objectives the VCU generation is very important. A reduction of 2,396,305.31 tCO_2e of GHG is expected over the next six years for the first baseline developed and presented in this PD, associated with the avoided deforestation of 6,167.07 ha. Also the total GHG emission reductions and removals of 4,136,504.49 tCO2e over the 30 years crediting period, representing an annual average GHG emission reductions and removals 137,883.48 tCO2e. In addition, validation of the TdX REDD+ project will occur on the date described in Table 1.1, which will also include all monitoring periods.

Table 1.1 Audit history

Audit Type	Period	Program	VVB Name
Validation	09-April-2023	VCS	Earthood Services Private Limited

1.2 Sectoral Scope and Project Type

The Triunfo do Xingu Grouped REDD+ Project is within the sectorial scope number 14 – Agriculture, Forestry and Other Land Use (AFOLU).

The project category is Reduced Emissions from Deforestation and Forest Degradation (REDD), more specifically, Avoiding Unplanned Deforestation (AUD project activity).

This project is a grouped project.

1.3 Project Eligibility

According to the VCS Standard v4.4 ("Verified Carbon Standard, v4.4," 2022) and considering the TdX project characteristics, four main sections must be followed by this project so it can be eligible. All the bullet points of the next paragraphs have, in their beginning, the VCS Standard section that sets a specific requirement, and then a brief description of how this project attends it.

Section 3.1 General Requirements

The project attends to all the applicable requisites of section 3.1 as listed below.

- Section 3.1.1: The project meets all applicable rules and requirements set out under the VCS program. More details about the methodology are given in section 3.2, Applicability of Methodology.
- Section 3.1.2: A methodology eligible under the VCS Program is applied in full, namely, the Methodology for Avoided Unplanned Deforestation v1.1. (VM0015, (VERRA, 2012a)).
- Section 3.1.3 The project has applied the latest version of the applicable methodology (VM0015, (VERRA, 2012a)), and will update to the latest version of the methodology when reassessing the baseline and renewing a crediting period.

- Section 3.1.4: Implementation is legal under Brazilian legislation. All laws considered during the compliance process are presented in section 1.14 of this document. Therefore, the project does not lead to the violation of any applicable law, regardless of whether or not the law is enforced.
- Section 3.1.7: Rules and requirements of the VCS program take precedence over other approved GHG Program when there is a conflict between them.
- Section 3.1.8: All capacity limits and relevant requirements are considered when a methodology from an approved GHG program is used.
- Section 3.2.10: A non-permanence risk report was developed and is available together with this project description validation document.
- Section 3.2.11 to 3.2.22: All the forementioned topics 3.2.11 to 3.2.22 of the VCS Standard v4.4 regarding the non-permanence risk report are followed by this project and can be seen in it..

Section 3.2 AFOLU-Specific Matters

All applicable minor sections of the 3.2. section have requirements followed by the TdX project:

- Section 3.2.2: The project is not located within a region covered by a jurisdictional REDD+ program, then it is not necessary to follow the requirements related to nested projects set out in the VCS Program document called Jurisdictional and Nested REDD+ Requirements.
- Section 3.2.3: All implementation partners are identified in section 1.6, Other Entities Involved in the Project, of this document.
- Section 3.2.4: Project activities do not convert native ecosystems to generate GHG credits. As stated in section 1.13 and confirmed by geospatial data, the land has not been cleared of native ecosystems within 10 years of the project start date. The geospatial analysis also concludes that fauna and flora of the project area are part of the Amazon Biome.
- Section 3.2.5: Project activities do not drain or degrade hydrological functions to generate GHG credits. Their resources are not used, and their riparian forest remains intact.
- Section 3.2.7 and 3.2.8: The project is going to reassess the defined baseline every six years in order to consider possible methodologies updates and changes in the drivers and/or behavior of agents that cause changes in the reference area.
- Section 3.2.9: Project activities do not occur on wetlands, then specific requirements for WRC projects are not necessary to be followed.

Section 3.6. Project Design

Since this is a grouped project, specific design requirement needs to be followed. The most important of them and the applicable ones are listed below. To complete description of those requirements and their attendance by each project instance is detailed in the next section 1.4.

- Sections 3.6.2, 3.6.3 and 3.6.19: The REDD AUD project activity is specified in the PD with its relevant methodology. All criteria and procedures set out on those were applied to demonstrate the baseline scenario and additionality. Also, a non-permanence risk report was made and presented together with this PD.

- Section 3.6.10: The project has one clearly defined geographic area.
- Sections 3.6.11, 3.6.13, and 3.6.14: There is one instance in this validation document. Its additionality and baseline scenario sets out the reference for the next ones. They are presented for the only designated geographic area of the project.
- Section 3.6.12: This project does have only one project activity (AUDD).
- Section 3.6.9. The capacity limits of the project activity are not exceeded by any project instance.
- Sections 3.6.16 and 3.6.17: A set of eligibility criteria is set in the next section 1.4 for every TdX project instance. Also, the eventual inclusion of new project instances follows all the requirements of the VCS Standard for project instances.
- Section 3.6.22: This single project description has all the TdX project instances. It contains the delineation of geographic areas in which project activities occur, the baseline and additionality demonstrations, sets of eligibility criteria and a description of the central GHG information system.

Appendix 1 Eligible AFOLU Project Categories

Appendix 1 from the VCS Standard v4.4 details the eligibility criteria for every type of activity. Since the Triunfo do Xingu is a Grouped REDD+ project, paragraphs A1.5 to A1.8 are the important ones for this project. The requirements attended by TdX are listed below.

- Reduce emissions from unplanned deforestation by avoiding illegal squatters to invade the property to transform forest land into non-forest land in a direct human-induced conversion.
- The eligible area is composed of qualified forests once they have more than 10 years of existence prior to the project start date.
- The activities covered under the REDD project category have specifically the goal to avoid unplanned (unsanctioned) deforestation (the project does not include degradation), configurating as an AUD kind of project.

1.4 Project Design

Following the template provided, TdX design fits in the option marked below.

☐ The project includes a single location or installation only.

☐ The project includes multiple locations or project activity instances but is not being developed as a grouped project.

☒ The project is a grouped project.

Eligibility Criteria

At the present stage this project is composed by multiple areas, but only one project activity instance. This first instance (hereinafter also referred as TdX-I1) has seven properties: six of them are adjacent to another and have the same owner, then there is the seventh one 40 km distant from the others and with another landowner. Detailed information about landowners and their properties localization are available in sections 1.6, 1.7 and 1.12. The possibility of adding new instances is open for the future.

According to the elements mentioned in section 3.6.16 of the VCS Standard v4.4, new areas willing to become new project activity instances of the project shall comply with the applicability conditions of the selected methodology, including conditions applicable to each activity. Also, new project activity instances must comply with the defined set of eligibility criteria.

Table 1.2 contains the VCS general requirements that the project shall comply with in the left column and the project attendance in the right column.

Table 1.2 TdX attendance of the VCS general requirements

VCS Standard Eligibility requirement	Project attendance
3.1.1. Projects shall meet all applicable rules and requirements set out under the VCS Program.	The TdX project meets all rules and requirements of the VCS Standard and the applied Methodology for Avoided Unplanned Deforestation v1.1, the VM0015.
3.1.2. Projects shall apply methodologies eligible under the VCS Program.	The TdX project applies in full the VM0015, which is eligible under the VCS Program and available on the Verra website.
3.1.3 Projects shall apply the latest version of the applicable methodology in all cases unless a grace period applies to the project as set out in 3.21 below. Projects must update to the latest version of the methodology when reassessing the baseline and renewing a crediting period.	The TdX project has applied the latest version of the applicable methodology (VM0015, (VERRA, 2012a)), and will update to the latest version of the methodology when reassessing the baseline and renewing a crediting period.
3.1.4. Projects and the implementation of project activities shall not lead to the violation of any applicable law.	The TdX project is implemented considering all Brazilian law requirements. The attendance to all the pertinent laws is clarified in section 1.14. Evidence is available attached[1].

[1] Annex: 230314_TdX Proof of Title.zip

VCS Standard Eligibility requirement	Project attendance
3.1.5. Where projects apply methodologies that permit the project proponent its own choice of model, such model shall meet the requirements set out in the VCS Program document VCS Methodology Requirements. 3.1.6. Where projects apply methodologies that permit the project proponent to choose a third-party default factor or standard to ascertain GHG emission data and any supporting data for establishing baseline scenarios and demonstrating additionality, such default factor or standard shall meet the requirements set out in the VCS Program document VCS Methodology Requirements.	Not applicable.
3.1.7. Where the rules and requirements under an approved GHG program conflict with the rules and requirements of the VCS Program, the rules and requirements of the VCS Program shall take precedence.	The project takes precedence to the rules and requirements of the VCS program over other approved GHG Program when there is conflict between them.
3.1.8. Where projects apply methodologies from approved GHG programs, they shall conform with any specified capacity limits and any other relevant requirements.	The project considered all capacity limits and relevant requirements when a methodology from approved GHG program is used.
3.2.2. Where projects are located within a jurisdiction covered by a jurisdictional REDD+ program, project proponents shall follow the requirements in this document and the requirements related to nested projects set out in the VCS Program document Jurisdictional and Nested REDD+ Requirements.	The project is not located within a region covered by a jurisdictional REDD+ program.
3.2.3. Where an implementation partner is acting in partnership with the project proponent, the implementation partner shall be identified in the project description.	All implementation partners are identified in section 1.6. “Other Entities Involved in the Project of this document” with their responsibilities within the project.
3.2.4. Activities that convert native ecosystems to generate GHG credits are not eligible under the VCS Program.	Project activities does not convert native ecosystems to generate GHG credits, this is also stated in section 1.13.
3.2.5. Activities that drain native ecosystems or degrade hydrological functions to generate GHG credits are not eligible under the VCS Program.	Project activities does not drain or degrade hydrological functions to generate GHG credits. Their resources are not used, and their riparian forest remain intact.
3.2.6. The project proponent shall demonstrate that project activities that lead to the intended GHG benefit have been implemented during each verification period in accordance with the project design.	Not applicable yet, but in the first verification report, the demonstration that project activities that lead to the intended GHG benefit will be presented.

VCS Standard Eligibility requirement	Project attendance
3.2.7. For all AUDD, APDD (where the agent is unknown), AUC and AUWD project types, the project proponent shall, for the duration of the project, reassess the baseline every six years and have this validated at the same time as the subsequent verification.	Six years from the current project description validation, the project is going to reassess the baseline defined in order to consider possible methodologies updates and changes in the drivers and/or behavior of agents that cause changes in the reference area.
3.2.9. Where ARR, ALM, IFM or REDD project activities occur on wetlands, the project shall adhere to both the respective project category requirements and the WRC requirements.	Not applicable. According to the methodology VM0015 v1.1., some examples of wetlands are bottomland forests, floodplain forests or mangrove forests. Then, considering the MapBiomas vegetation classification[2] it's possible to conclude that the project area do not involve wetlands[3].
3.2.10. Projects shall prepare a non-permanence risk report in accordance with the VCS Program document AFOLU Non-Permanence Risk Tool at both validation and verification. 3.2.11 to 3.2.22.	A non-permanence risk report was developed and is available together with this project description validation document. All the forementioned topics 3.2.11 to 3.2.22 of the VCS Standard v4.4 regarding the non-permanence risk report are followed by this project and can be seen in it.
3.6.8 The project proponent shall include in a singular project all project activity instances within ten kilometers of another instance of the same project activity and with the same project proponent	Systemica (project proponent) does not have any other project with the same project activity and within ten kilometers of the first project activity instance to be included in this project.
3.6.9 Where a capacity limit applies to a project activity included in the project, no project activity instance shall exceed such limit. Further, no single cluster of project activity instances shall exceed the capacity limit, determined as follows: 1) Each project activity instance that exceeds one percent of the capacity limit shall be identified. 2) Such instances shall be divided into clusters, whereby each cluster is comprised any system of such instances such that each instance is within one kilometer of at least one other instance in the cluster. Instances that are not within one kilometer of any other instance shall not be assigned to clusters.	This grouped project has only one project activity (AUDD) and the TdX-I1 (first project activity instance) does not exceed its limits.

[2] Annex: 221014_Cod_Class_label_Col6_MapBiomas_BR.pdf

[3] Annex: 221014_mapbiomas-classification.jpeg

VCS Standard Eligibility requirement	Project attendance
3) None of the clusters shall exceed the capacity limit and no further project activity instances shall be added to the project that would cause any of the clusters to exceed the capacity limit.	

Table 1.3 contains the general requirements for grouped project and the defined set of eligibility criteria for new project activity instance for the TdX Grouped REDD+ project, as well as the attendance of the TdX-I1 (first project activity instance)

Table 1.3 TdX set of eligibility criteria and the attendance of the 1st Project Activity Instance.

VCS Standard Eligibility for Grouped Project	TdX Project Activity Instances
About grouped project baseline scenario and additionality: 3.6.10. Grouped projects shall specify one or more clearly defined geographic areas within which project activity instances may be developed. 3.6.11. Determination of baseline scenario and demonstration of additionality are based upon the initial project activity instances. 3.6.12. As with non-grouped projects, grouped projects may incorporate multiple project activities. 3.6.13. The baseline scenario for a project activity shall be determined for each designated geographic area, in accordance with the methodology applied to the project 3.6.14. The additionality of the initial project activity instances shall be demonstrated for each designated geographic area, in accordance with the methodology applied to the project. 3.6.15. Where factors relevant to the determination of the baseline scenario or demonstration of additionality require assessment across a given area, the area shall be, at a minimum, the grouped project geographic area.	This grouped project has one clearly defined geographic area within this first instance developed. The determinations of the baseline scenario and the additionality were based upon the initial project activity instance: avoiding unplanned deforestation, also described in section 3.4 and 3.5. Although it could, this project does not have any other project activities besides the AUDD. This project has only one geographic area, then, additionality and the baseline scenario were assessed only once for this project instance.
3.6.16. Grouped projects shall include one or more sets of eligibility criteria for the inclusion of new project activity instances. A set of eligibility criteria shall ensure that new project activity instances: 1) Meet the applicability conditions set out in the methodology applied to the project. 2) Use the technologies or measures specified in the project description. 3) Apply the technologies or measures in the same manner as specified in the project description.	This table has a set of eligible criteria for the inclusion of new project activity instance in the TdX project. It is also ensured that new project activity instance and the TdX-I1: • Meet the applicability conditions set out in the methodology applied to the project. • Uses technologies or measures specified in the project description and in the same manner as their description.

4) Are subject to the baseline scenario determined in the project description for the specified project activity and geographic area. 5) Have characteristics with respect to additionality that are consistent with the initial instances for the specified project activity and geographic area. For example, the new project activity instances have financial, technical and/or other parameters.	• Is subject to the baseline scenario determined in the project description for the specified project activity in the geographic area. • Sets out the characteristics for financial, technical and/or other parameters used by additionality of this project. Eventual new instances need to be consistent with this first instance.
3.6.17. New project activity instances shall: 1) Occur within one of the designated geographic areas specified in the project description. 2) Conform with at least one complete set of eligibility criteria for the inclusion of new project activity instances. 3) Be included in the monitoring report with sufficient technical, financial, geographic, and other relevant information to demonstrate conformance. 4) Be included in an updated project description, with updated project location information, which shall be validated at the time of verification against the applicable set of eligibility criteria. 5) Have evidence of project ownership, in respect of each project activity instance, 6) Have a start date that is the same as or later than the grouped project start date. 7) Be eligible for crediting from the start date of the project activity instance through to the end of the project crediting period (only). 8) Only eligible for crediting from the start of the verification period in which they were added to the grouped project. 9) Not be-or have enrolled in another VCS project. 10) Adhere to the clustering and capacity limit requirements for multiple project activity instances set out in 3.6.8 - 3.6.9.	New TdX project activity instance: 1. Will occur in the designated geographic area specified in the project description. 2. Will be in conformance whit this defined set of eligible criteria. 3. Will be included in the monitoring report. 4. Is going to be included in an updated project description, with updated project location information, which will be validated by the VVB contracted. 5. Will have evidence of project ownership. 6. Will have the same start date as or later than the TdX grouped project and 7. Will be eligible through all the project activity instance crediting period. 8. Will be eligible for crediting from the start of the verification period in which they were added to the TdX grouped project. 9. Will not be or have been enrolled in another VCS project. 10. Will adhere to the clustering and capacity limit requirements. The TdX-I1: • Occurs in the designated geographic area specified in the project description. • Comply whit this set of eligible criteria presented by this Table. • As this is the first instance, it is already included in this PD.

	• Is going to be validated by the VVB contracted. • Have evidence of project ownership, presented in section 1.7. of the PD. • Have the same start date that as the grouped project and is eligible through all the project crediting period. • Will not leave the VCS project and then enroll in another one.
3.5.17. AFOLU non-permanence risk analyses, where required, shall be assessed for each geographic area specified in the project description.	The AFOLU non-permanence risk analyses will be assessed for each new project activity instance. The TdX-I1 required non-permanence risk analysis is available together with this PD.

1.5 Project Proponent

The project proponent detailed information is shown in Table 1.4.

Table 1.4. Project proponent detailed information.

Organization name	Systemica (MYS E JLFL TREINAMENTO GERENCIAL LTDA)[4]
Contact person	Munir Younes Soares
Title	Director
Address	Rua São Vicente de Paulo, nº 501, Apartamento 201, Jardim Paulista, São Paulo, Brazil. Postal Code: 01229-010.
Telephone	+55 (11) 99394-1980
Email	munir@systemica.digital

1.6 Other Entities Involved in the Project

The entity involved detailed information is shown in Table 1.5, Table 1.6, and Table 1.7.

Table 1.5. Byblos Agronegócio Holding Ltda entity detailed information.

Organization name	BYBLOS AGRONEGÓCIO HOLDING LTDA.

[4] Annex: 221014_VCS-Listing-Representation-Single-Representor-v4.1 – TdX.pdf

Role in the project	Landowner[5] and partner in the project activity implementation.
Contact person	RAFAEL BEMERGUY SEFER
Title	Owner of the Patacho and Campo Lindo farms
Address	Rua Tv SOL D'Oeste, S/N, Sala C, Liberdade, Marabá – PA, Brazil, CEP 68.501-730
Telephone	+55 91 9353-1020
Email	rafaelsefer@hotmail.com

Table 1.6. Santa Maria Pecuaria e Agronegocio Ltda entity detailed information.

Organization name	SANTA MARIA PECUARIA E AGRONEGOCIO LTDA.
Role in the project	Landowner and partner in the project activity implementation.
Contact person	RAFAEL BEMERGUY SEFER
Title	Owner of the Belcon, Santa Marta, Retiro Encantado and Vó Lina farms
Address	Rua Tv SOL D'Oeste, S/N, Sala C, Liberdade, Marabá – PA, Brazil, CEP 68.501-730
Telephone	+55 91 9353-1020
Email	rafaelsefer@hotmail.com

Table 1.7. Didácio Milhomens Barros entity detailed information

Organization name	DIDÁCIO MILHOMENS BARROS
Role in the project	Landowner[6] and partner in the project activity implementation.
Contact person	DIDÁCIO MILHOMENS BARROS
Title	Owner of the Nossa Senhora Aparecida farm
Address	QSC 19, Chácara 25, Conjunto F, Lote 11, Taguatinga, Distrito Federal, Brazil, CEP: 72.017-221

[5]Annex: 221226_Systemica-Sefer contract.pdf

[6] Annex: 221014_Systemica-Didácio contract.pdf

Telephone	+55 61 8406-5165
Email	didmilhomens@yahoo.com.br

1.7 Ownership

The grouped project covers a region in the municipalities of Altamira, in the States of Pará, Brazil. The initial area is located in a private property named "Nossa Senhora Aparecida Farm", owned by Didácio Milhomens Barros. The legal documents proving the land title and ownership of each property will be made available to the auditors during the validation process.

The six other properties that compose the first instance of the Triunfo do Xingu REDD+ Project have Rafael Sefer as owner under two different companies. The properties "Belcon Farm", "Santa Marta Farm", "Retiro Encantado Farm" and "Vó Lina Farm" are owned by Santa Maria Pecuaria e Agronegócio Ltda. "Patacho Farm" and "Campo Lindo Farm" are possession of Byblos Agronegócio Holding Ltda. All these six areas are in process of land title and ownership regularization in the Land Institute of Pará (Instituto de Terras do Pará - ITERPA), the responsible public office in the State of Pará.

Although the areas still do not have the property title, an achievement of the project is the acceleration of the land regularization process, and when we analyze the processes in ITERPA[7] of all the properties it is possible to affirm that the conclusion will be the issuance of the correct title. At the current stage of the process, the State of Pará has already issued a declaration in favor of granting the title. The ITERPA's Agrarian and Land Development Board (DEAF) decided that the areas are occupied by the owner, the divisions are correct, and the titling claim is valid.

The legal documents or the full copy of the processes in ITERPA, evidencing ownership of the project properties will be made available to the auditors during the validation process. As Sefer properties land tenure is not secured during the project validation due to the title regularization processes described in this section, this will be left for review in the first verification process. This decision is made based on section 3.11.4 of the VCS Standard v4.4, second paragraph "Where the project proponent does not yet have control over the entire area at validation, the entire project area (that shall be specified in accordance with Section 3.11.2) is to be validated as if it were under control and the project is ready to be implemented". Then, the decision to make the titles available in future reports has support in Verra methodologies.

1.8 Project Start Date

The Triunfo do Xingu grouped REDD+ project started on the 31st of August 2022. This date represents the effective date on which the project began generating GHG emissions reduction in the project area.

The VM0015 methodology (VERRA, 2012a) adopted states in Section 1.2.2 that the start date is the date when additional activities have started to avoid unplanned deforestation. Then, despite a lot of previous

[7] Annex: 230314_TdX Proof of Title.zip

conversations with landowners and project viability analysis, the 31st of August 2022 represents the first date when local activities started to be implemented by Systemica. Evidence[8],[9] shows that presential meetings were done to present the TdX project, to bring elements of environmental education to local communities near the project areas, develop REDD+ capacity building activities and to understand their opinion about it. This is one of the many activities proposed by the TdX project. Engaging the local community helps to spread the existence of REDD+ to them, which is still not very popular among the larger amount households of the Amazon biome, and then, show them the benefits the project implementation can bring not only to the environment, but also to the local communities.

1.9 Project Crediting Period

The project has a crediting period of 30 years, starting on 31th of August 2022 to 30th of August 2052.

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

The TdX project is "project" scale denominated by the generation of the less than or equal to 300,000 tonnes of CO_{2e} per year (Table 1.8) according to the VCS Standard v4.4 in section 3.10. The estimated annual GHG emission reductions or removals for the project crediting period is estimated in this verification process by 30 years period-based considering the current deforestation pattern (Table 1.9).

Table 1.8. Project Scale

Project Scale	
Project	X
Large project	-

Table 1.9. Estimated annual GHG emission reductions or removals for the project crediting period

Year	Period	Estimated GHG emission reductions or removals (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
2022	2022-2023	36,656.64	29,015.66
2023	2023-2024	559,946.57	443,238.96
2024	2024-2025	400,740.29	317,277.76
2025	2025-2026	254,272.89	201,295.58
2026	2026-2027	480,497.59	380,348.58
2027	2027-2028	664,191.34	525,793.70
2028	2028-2029	303,986.96	240,658.45
2029	2029-2030	905,263.43	716,571.41
2030	2030-2031	234,145.43	185,409.22
2031	2031-2032	296,803.36	234,973.68

[8] Annex: 230515_REDD+_Capacity_Building.zip

[9] Annex: 221014_First project implementation activity.pdf

Year	Period	Estimated GHG emission reductions or removals (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
2032	2032-2033	-	-
2033	2033-2034	-	-
2034	2034-2035	-	-
2035	2035-2036	-	-
2036	2036-2037	-	-
2037	2037-2038	-	-
2038	2038-2039	-	-
2039	2039-2040	-	-
2040	2040-2041	-	-
2041	2041-2042	-	-
2042	2042-2043	-	-
2043	2043-2044	-	-
2044	2044-2045	-	-
2045	2045-2046	-	-
2046	2046-2047	-	-
2047	2047-2048	-	-
2048	2048-2049	-	-
2049	2049-2050	-	-
2050	2050-2051	-	-
2051	2051-2052	-	-
Total estimated Ers		4,136,504.49	3,274,583.01
Total number of crediting years		30.00	
Average annual Ers		137,883.48	109,152.77

1.11 Description of the Project Activity

The Triunfo do Xingu Grouped REDD+ Project aims to conserve native ecosystems of the Amazon rainforest located within the municipality of Altamira, in Pará state, Brazil. To reach this goal, actions will be taken to avoid unplanned deforestation. It is important to state that none of those areas are located within a jurisdiction covered by a jurisdictional REDD+ program.

This project description as a validation document has one instance composed by six properties owned by Rafael Sefer, and seventh one called Nossa Senhora Aparecida Farm. They have, respectively, 9,229.23 ha and 1,406.79 ha of forest area. With the TdX project, it is expected to avoid 2,396,305.31 tons of equivalent CO_2 in emissions over the first baseline period of six years. In the future, new instances may be added to the project, expanding the conservation of the forest.

The main deforestation agents within the TdX are mainly illegal squatters that execute logging activities followed by cattle ranching. Sometimes timber extraction takes place, but most of the time the wood is simply burned.

To mitigate the risk of illegal actors the main measures that are going to be adopted are the expansion of monitoring the area, mapping of deforestation, partnerships with education and research institutions, and the insertion of the surrounding communities in the project activities, aiming to minimize invasions and illegal deforestation, offering alternative income, education and professional training. More details of these actions are given below.

Patrolling and surveillance.

The protection of the forest area is the project's main activity and objective, in order to avoid unplanned deforestation, given that the project area is located in a region with high deforestation rates. A detailed monitoring plan is going to be created. Based on previous experience, it is expected that the most recurrent positive impact perceived by the people from the adjacent community will be the tenure security as a result of the project operations.

The mitigation of possible conflicts, resulting from illegal occupation of the project area by land grabbers or from the invasion of the project properties, will be carried out through the identification of strategic points to establish surveillance checkpoints prioritizing zones bordering areas with high probability of invasion, i.e., areas that have historically presented this type of event. Also, physical markers made of solid materials such as wood and concrete will be erected along the perimeter of the properties, each featuring a georeferenced marking that indicates its precise location within the property, and a monthly frequency for the surveillance rounds will be established.

Satellite monitoring

The approach adopted by the project involves a system combining satellite images with field visits. The monitoring plan will use the Mapbiomas Alert data, which is a system that validates and refines deforestation alerts with high-resolution images by integrating and analyzing multiple alert systems, such as DETER, PRODES, SAD, Sirad-X, and others. This platform data is widely used because it integrates and validates the alerts of several products increasing the reliability of the data and can be acquired on a daily frequency.

Leakage control

The project proponent together with the landowners comprehends the conceptual complexity and difficulties of implementing a policy for preventing potential leakage. Therefore, the Project proponents will adopt a proactive initiative for fighting leakage sources. This adoption will be based on a cooperative effort with local stakeholders to promote a new approach to forest use and land use in the region. To objective of those efforts will be directed to raise awareness among the stakeholders leaving in the nearby areas (Caboclo Village) about environmental education. In order to mitigate leakage, the Project proponents foresee continuous remote monitoring of the areas surrounding the Project (Leakage belt) and interventions with the local stakeholders in the surrounding areas (Caboclo Village)..

Although there is a risk of leakage, the proponents believe that the Project will have positive impacts on surrounding areas. This Project might be a well-succeeded example of: (i) financial return due to REDD incentives, which can compensate for avoiding deforestation for other activities; (ii) maintenance of real estate (land acquisition and grabbing dynamics).

Maintenance of firebreaks

To prevent outside wildfires from entering the project forest area, the maintenance of firebreaks will be an important factor in managing wildfires. The landowners are committed to maintaining firebreaks on the project properties. Firebreaks are very effective technique commonly employed in the region to contain and prevent fires, and are largely recommended by the fire department and IBAMA (2009). Regarding the implementation and maintenance of firebreaks, the fire department has developed technical material that is easy to access on techniques, dimensions and practical notions for the construction of firebreaks (PMESP, 2006).

Potential roll-out to other areas

The Project might probably stimulate other landowners to adhere to his concept. Communication with landowners might be performed using associative actions and environmental education. Other areas with the potential to be included in REDD projects have already been identified around the project site, which will favor and encourage forest conservation by means of financial incentives obtained from reduced emission sales and provide social and environmental benefits to neighboring communities.

Employing Project monitoring activities; we believe that the well-succeeded example of this business plan will generate an increased number of sustainably managed areas, which will create ancillary benefits around the Project boundary.

Contact with neighboring communities

The project activity will consist of lectures, environmental education activities, and an emphasis on the importance of forests, all with the goal of keeping the forests intact. The project proponent will carry out these activities by engaging with the surrounding communities. By reaching out to local communities and developing activities with the purpose of raising awareness about the importance of preserving forests, they can have a significant impact on the maintenance of these vital ecosystems. Through this direct interaction, the proponent aims to promote environmental sensibility and awareness, ultimately contributing to the long-term preservation of the forests.

1.12 Project Location

The Triunfo do Xingu Grouped REDD+ Project's area is situated in Altamira municipality, Pará state, Brazil. This municipality is 832 km far from Belém, the capital of the state of Pará. Its estimated population, based on the IBGE estimates of 2021, is around 117 thousand inhabitants, and its territorial area averages 160 thousand square kilometers, equivalent to 1,6 x 10^9 hectares.

Following the VCS Methodology VM0015 v1.1 (VERRA, 2012a), the project area may only include areas composed of forest for a minimum of ten years prior to the project start date, a definition that also includes secondary forests. Therefore, satellite images between 2012 and 2022, were analyzed and classified and the areas within the property that were defined as forests were separated and utilized to compose the project area. In addition, some non-forest areas were also excluded, such as rivers, rocks, and non-forest vegetation.

The definition used for forest areas is the one given by the Food and Agriculture Organization of the United Nations (Ramírez & Morales, 2021): "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use".

Table 1.10 contains the location of each property part of the TdX-I1, it also describes the size of total property area and eligible forest area.

Table 1.10. TdX-I1: Properties centroid's locations coordinates and areas.

Ownership	Properties	Area (ha)	Project Area/Eligible Forest (ha)	Centroid location coordinates	
				Longitude	Latitude
Rafael Bemerguy Sefer	Belcon Farm	2,197.53	1,835.91	-53° 39′ 38.852″	-5° 37′ 55.445″
	Campo Lindo Farm	2,443.14	1,792.98	-53° 31′ 58.888″	-5° 41′ 56.909″
	Patacho Farm	2,135.16	1,901.16	-53° 39′ 21.781″	-5° 39′ 22.873″
	Retiro Encantado Farm	2,342.88	1,242.27	-53° 34′ 45.974″	-5° 42′ 42.604″
	Santa Marta Farm	2,450.34	1,355.40	-53° 37′ 48.865″	-5° 43′ 2.404″
	Vó Lina Farm	2,364.57	1,101.51	-53° 40′ 38.524″	-5° 41′ 15.775″
Didácio Milhomens Barros	Nossa Senhora Aparecida Farm	1,888.01	1,406.79	-53° 24′ 18.419″	-6° 8′ 1.763″
Total		15,813.63	10,636.02	-	-

Geodetic coordinates of all the project locations have been submitted in the annex[10, 11] as a KML file. The properties boundaries are also available in Figure 1.1. The six properties up north are owned by Rafael Sefer, the seventh southernmost is from Didácio Barros. The reddish areas are the eligible forests that compose the project area of instance 1.

[10] Annex: 221014_project_area_TdX.kml

[11] Annex: 221014_properties_area_TdX.kml

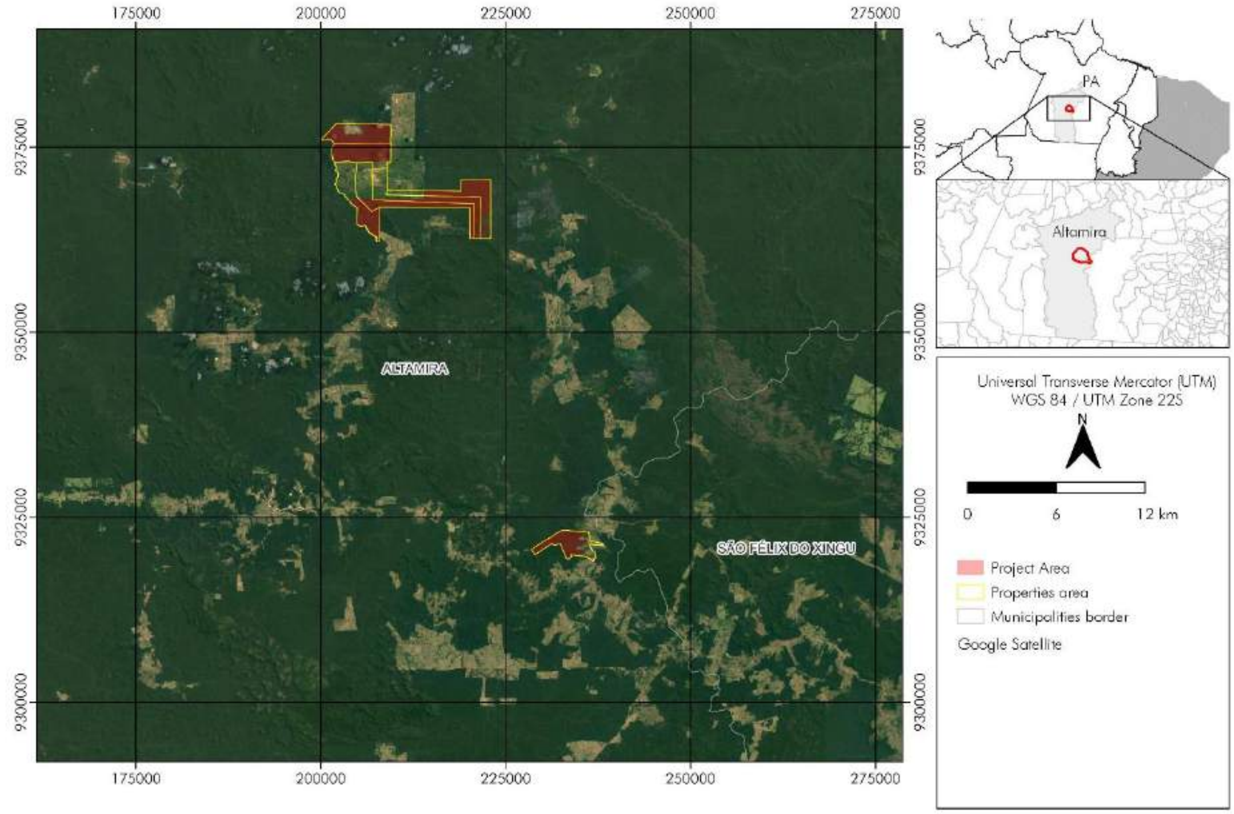

Figure 1.1. Map with both properties area perimeter in yellow and project area in red.

1.13 Conditions Prior to Project Initiation

Ecosystem type

The project area is composed of 100% native Amazon Rainforest vegetation and is divided of 2 main forest strata, the dense-canopy rainforest submontane and the open-canopy rainforest submontane.

Current and historical land-use:

There is no activity being conducted in the project area, which remains as native standing forest preserved for more than 10 years prior to the project start date. Also, there was no activity conducted in the project area in its historical land-use.

Has the land been cleared of native ecosystems within 10 years of the project start date?

☐ Yes ☒ No

1.13.1 Current and historical land-use

This REDD project is going to be implemented in a region with a previous history of deforestation pressure. The landowner requested carbon incentives to monitor the project area and avoid unplanned deforestation. As seen in Figure 1.2, the land was cleared of native ecosystems within 10 years of the project start date. In the project area, the presence of secondary vegetation was not identified. There hasn't been deforestation of native ecosystems in the last 10 years from the start date of the project. Although vegetation was removed on the property in a period of longer than 10 years, at the Belcon, Campo Limpo, Patacho, Retiro Encantado, Santa Marta and Vó Lina Farms in 2004, and the Nossa Senhora Aparecida Farm in 2009, this intervention was outside the project area and in a controlled way.

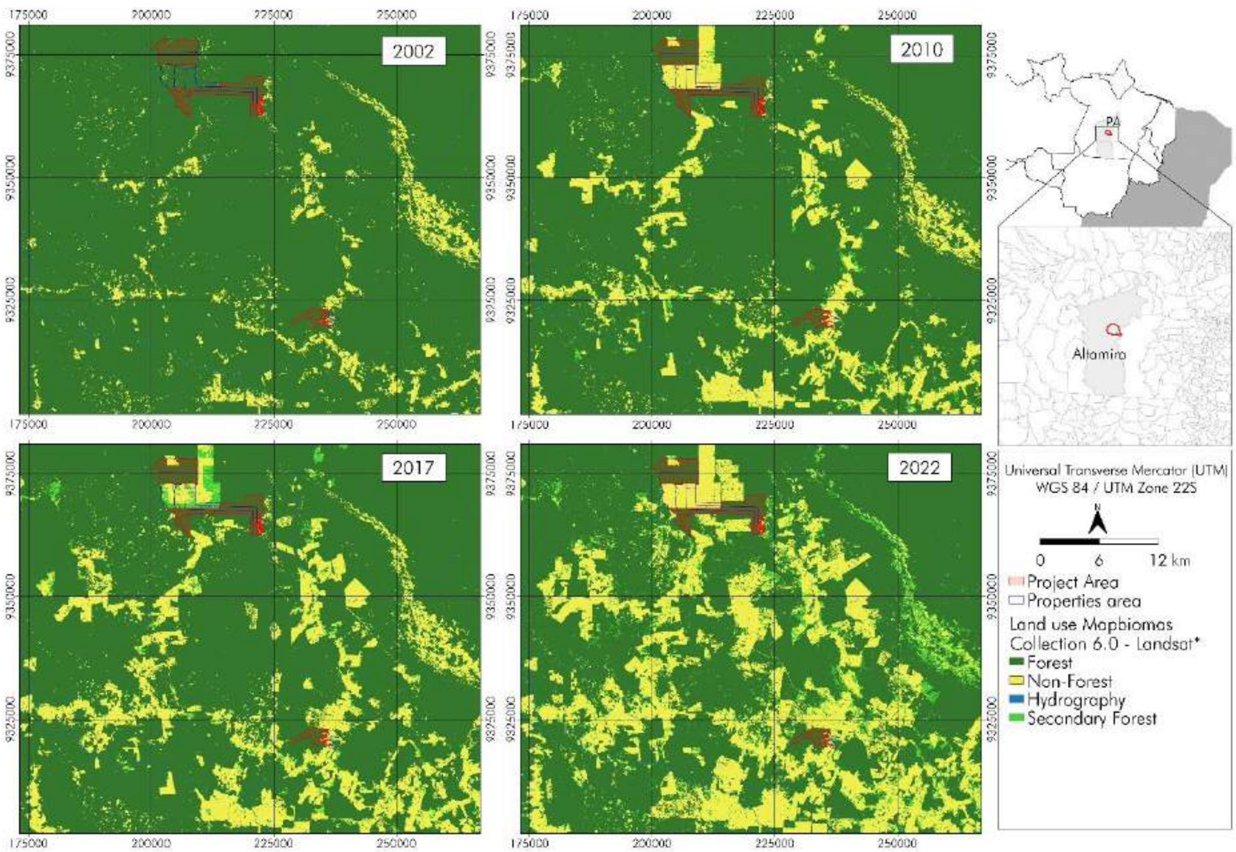

Figure 1.2. Forest coverage in 2002 (twenty years before the project start), 2010 (ten years before the project start), 2017 and 2022.

As seen in Figure 1.2 and confirmed in the graph in Figure 1.3, the main dynamics in land use is the conversion of areas of native vegetation to livestock, and the magnitude of the decrease of native vegetation while increased pasture lands show a huge pression in the around region of the Project Area. In this context, the project was characterized and still fits into the AFOLU REDD+ category to Avoid Unplanned Deforestation and Degradation (AUDD).

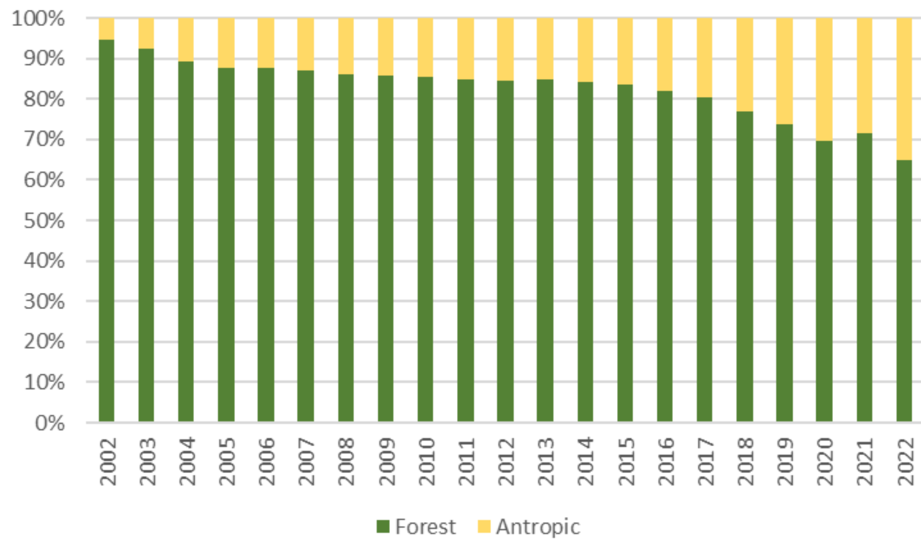

Figure 1.3: Increase of pasture lands showing huge pression deforestation around Project Area in Reference region (RR).

In the big picture, the Brazilian Legal Amazon region is under deforestation big deforestation pressure in its borders. An estimated 20% of its original forest has already been lost (CNN, 2021). From 2015 to 2019, over 61,000.0 km² of forests have been destroyed in the region (Assis et al., 2019), equivalent to 0.77% of its total territory. This configures as an increase in deforestation when compared to the previous five years period (data shown in Figure 1.4). Even though the decade of 2010-2019 has the lowest historic deforestation taxes, the recent increase shows that the situation still is far to be under control.

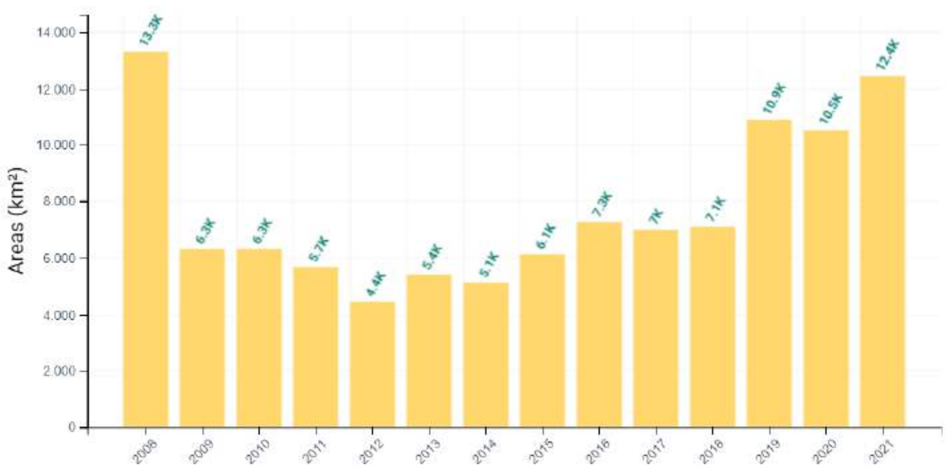

Figure 1.4: Deforestation areas in Brazilian Legal Amazon. From: Assis et al. (2019).

According to data from the Deforestation Alert System (SAD), from the Institute of Man and the Environment of the Amazon (Imazon), Pará is the state that most deforests in the Legal Amazon. In the last 12 months, from August 2021 to July 2022, 3,858 km² of forests in Pará were cut down, representing alone 36% of the deforestation in the Legal Amazon (IMAZON, 2022a).

In Pará, livestock is one of the main causes of deforestation, and its cattle herd is second only to Mato Grosso in size. The number of herds is seen as the main cause of deforestation in the Amazon, and the variation in the number of animals is accompanied, in part, by the expansion of pasture areas and the clearing of areas of dense forest (Castelo & Almeida, 2015).

According to data from the IBGE, the growth of the cattle herd in São Félix do Xingu, in the south of Pará, in 2020, still stands out nationally as the municipality with the highest number of cattle, with 2.4 million head of cattle and an increase of 5.4% in the year (IBGE, 2021d). In July, two of the four municipalities in Pará that were among the ten most deforested in the Legal Amazon are the municipalities of Altamira, with 81 km² and São Félix do Xingu, with a deforested area of 76 km². Together they represent a destruction of 157 km² of deforestation. São Félix do Xingu is the municipality with the largest herd in the state: 1.03 million head in 2001 and 2.02 million in 2010. Another prominent municipality is Altamira. Together they lead the ranking of municipalities that hold more than a third of the state's cattle herd (IMAZON, 2022a).

According to (MapBiomas, 2022), the municipality of Altamira, where the project is located, has 1.126.019 hectares occupied with pasture, which represents about 7.19% of the total municipality area, and 14,566,022 hectares occupied with forest, which represents about 91.30% of the total municipality area.

Research shows that deforestation in the municipalities of the state of Pará follows a worrying trend. The lower the deforestation, the lower the growth of the cattle herd (Castelo & Almeida, 2015). This deforestation has generated total emissions of approximately 6,47 billion tons of equivalent CO_2, an average of 308 million tons per year (Assis et al., 2019).

In this deforestation process, the first step is the forest clear-cutting and logging. It is estimated that 30% of this timber is subsequently converted into long-term wood products, the non-merchantable timber that remains in the field is usually accumulated and burnt prior to installation of pasture or agricultural activities. Most of carbon emissions from baseline activities occur during this operation. After burning the remnant forest biomass, the land is virtually clear and ready for other activities.

This corroborates the main dynamics in land use found in the region, where the conversion of areas of native vegetation into livestock stands out, and the magnitude of the decrease of native vegetation while the increase of pastures shows enormous pressure in the region of the TdX Project.

1.13.2 APA Triunfo do Xingu: Historic and Unplanned deforestation

The APA Triunfo do Xingu was established by State Decree 2.612 in 2006 (Figure 1.5), and is located in the municipalities of São Félix do Xingu (where 66% of the total area is located) and Altamira (34%), with approximately 1.68 million hectares and is part of the Amazon Protected Areas Program (ARPA), along with neighboring areas such as the Terra do Meio Ecological Station and the Serra do Pardo National Park (ISA, 2023).

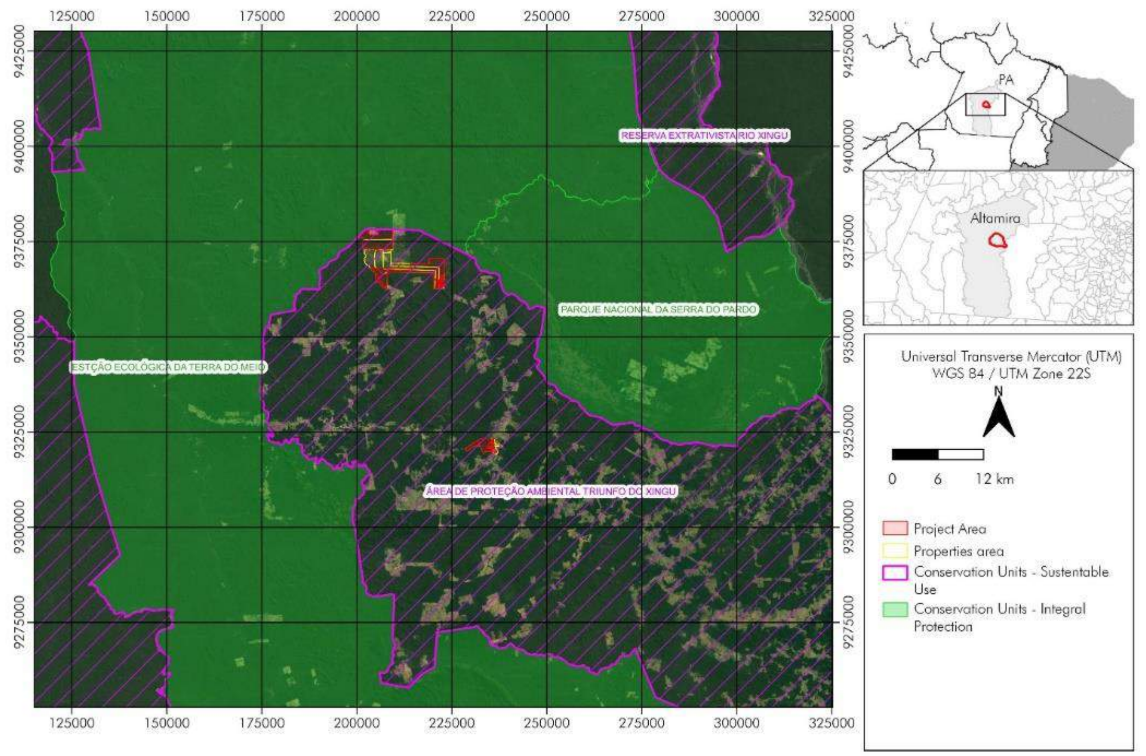

Figure 1.5: Location of the Triunfo do Xingu APA and the Project Area.

According to the survey of the study “Threat and Pressure of Deforestation in Protected Areas”, published quarterly by the Institute of Man and the Environment of the Amazon (Imazon) indicates that the Environmental Protection Area (APA) Triunfo do Xingu (PA) was the protected territory most pressured by deforestation in the first quarter of this year (Hashizume, 2021).

About 40% of the Triunfo do Xingu Environmental Protection Area (APA), formed by the Savanna-Ombrophilous Forest Contact, Dense and Open Ombrophilous Forest, have already been converted to other uses, mainly for livestock (COSTA, 2013; Hashizume, 2021).

One of the main factors linked to the exaggerated deforestation in this APA is the non-existent consolidation of a management and zoning plan. 15 years have passed since its creation and the scenario only worsened with the annual meetings of the Management Council: the last one with registered documents was in May 2019, and the penultimate one took place a year earlier, in May 2018, according to the page of the Institute for Forestry Development and Biodiversity of the State of Pará (Ideflor-Bio) (Hashizume, 2021; ISA, 2023).

In addition, APA Triunfo do Xingu has an issue involving very strong land grabbing in its territory. Big companies and large ranchers are pushing for more land, aggravating the conflict over resources, including access to water. And since this is an area that never had a management plan, consequently the conflicts were never resolved and any kind of intervention, especially the destruction of forests, is illegal (ISA, 2012). This situation is consequence of the east occupation front evolution in the region between the rivers Xingu and Iriri (COSTA, 2013). The deforestation pressure can be separated in:

- 1st phase. The minning company called Canopus explored a deposit of cassiterite, building its headquarters in the place that became the current Canopus Village.
- 2nd phase. Illegal logging activities through the years of 1986 to 1992. Big wood companies constructed north-south transport roadways in the central part of the Canopus roadway, that interligates the Xingu River with the Iriri River.
- 3rd phase. Ocupation by family farming, during 1993 to 1999. It evidenced the regional connectivity between the city of São Feliz do Xingu and the Transamazônica roadway. Family farmes bouthg land properties from ITERPA or directly of the previous owners, around the Canopus roadway, but not in the Canopus Village.
- 4th phase. Between 2000 and 2005, when the property of the Canopus company was invaded by farmes and ranchers. A previous agreement between ITERPA and the family farmers was not legitimated. Considering this situation, it was easier for bigger farmers to acquire more land through invasion, purchase or aggregation of small settler lots. In many, occasions, this was a violet process.
- 5th phase. The creation of the APA Triunfo do Xingu in 2006. It creates an immediate expectation for land use planning and contestation of land grabbing and deforestation activities.

The deforestation study carried out in the Reference Region (RR) located within the Triunfo do Xingu APA clearly illustrates the entire scenario and dynamics described in relation to the strong deforestation pressures that occur in this specific APA (Figure 1.6).

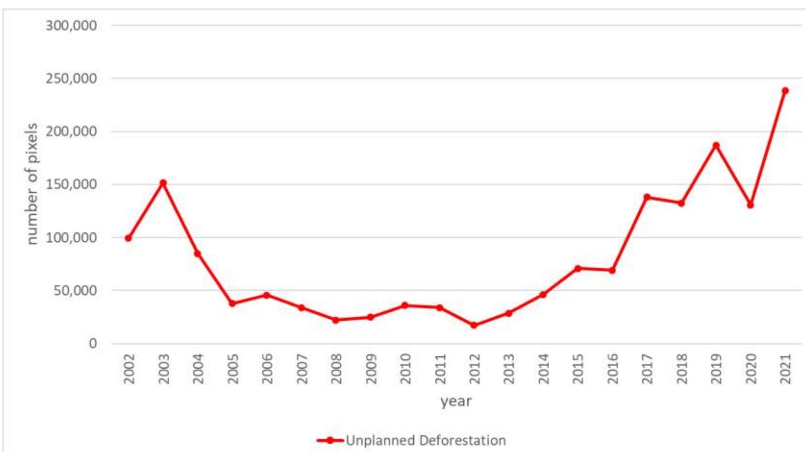

Figure 1.6: Data on unplanned deforestation, in number of pixels, recorded in the RR (within the APA Triunfo do Xingu) in the last two decades.

These conflicts and invasions have received attention and intervention from the government of Pará. The "Sustainable Territories" program was launched, based on a public notice for the registration of producers who will have special government assistance, presented as a pillar of the Amazônia Agora strategy with the participation of Ideflor -Bio and the Secretary of State for the Environment and Sustainability (Semas), among other bodies within the APA. The municipality of São Félix do Xingu also highlighted the creation of the initiative, aimed at registering and supporting "good practices" (Hashizume, 2021).

That said, it is evident that the invaded areas, especially the local communities, are recognized by the municipality and are on the way to registration and formalization.

1.13.3 Communities

The Canopus Village and Caboclo Village communities belong to the territory of Altamira, 1,400 kilometers away from the municipal seat. Cabloco Village, in particular, is located close to the properties that are part of the Triunfo do Xingu Grouped Redd+ Project, Belcon Farms, Campo Limpo, Patacho, Retiro Encantado, Santa Marta and Vó Lina at a distance of 60 kilometers, and 8 km from Nossa Senhora da Aparecida Farm.

The Caboclo Village community is a rural village, where most residents live from subsistence farming and the provision of rural services, with most of the local labor allocated during harvest periods, or in work related to rural properties of region. The village has about 90 to 100 inhabitants (Annex Carol; AMARAL et al., 2006). Due to its proximity to one of the projects in the project (N. Sra. Aparecida Farm), Caboclo Village will be the priority target for implementing the planned actions.

Caboclo Village has a public health structure, a fuel station, and an arrivals station (Amaral, Monteiro, Câmara, Escada, & Aguiar, 2006). Its importance for the local population has been recognized and it has received investments from the local City Council, which announced several works and services in these locations. Meetings with the community have also been held by the city hall, to survey the demands of health, education, agriculture, works and services that will be met to improve the quality of life and infrastructure for the local community. It is worth mentioning that the region has received investments in part from royalties, where part of the profits obtained from the use of water resources from the Belo Monte Hydroelectric Power Plant for programs and actions of the Municipal Executive (PMA, 2021).

Canopus Village has greater importance and influence and is located, especially due to its strategic location. It also plays an important role in the process of transforming the territory, expressed, for example, in the deforestation activity in its surroundings (Amaral et al., 2006), Canopus Village is located in RR, at a distance of about 60 km away from the headquarters of the Santa Maria farm. It is an area of land invasion and land grabbing that occurred mainly during the 1980s, and whose population currently lives mainly from cattle ranching and illegal mining (COSTA, 2013), as also confirmed by our field researchers and documented in Section 2.

Because it is a very sensitive area, and there are eminent conflicts, the approach strategies need to be very well planned, in order to guarantee that the project team makes a participatory diagnosis possible, without getting into friction with the leaders of the project. illegal mining, which seem to operate with great capillarity and influence throughout the region.

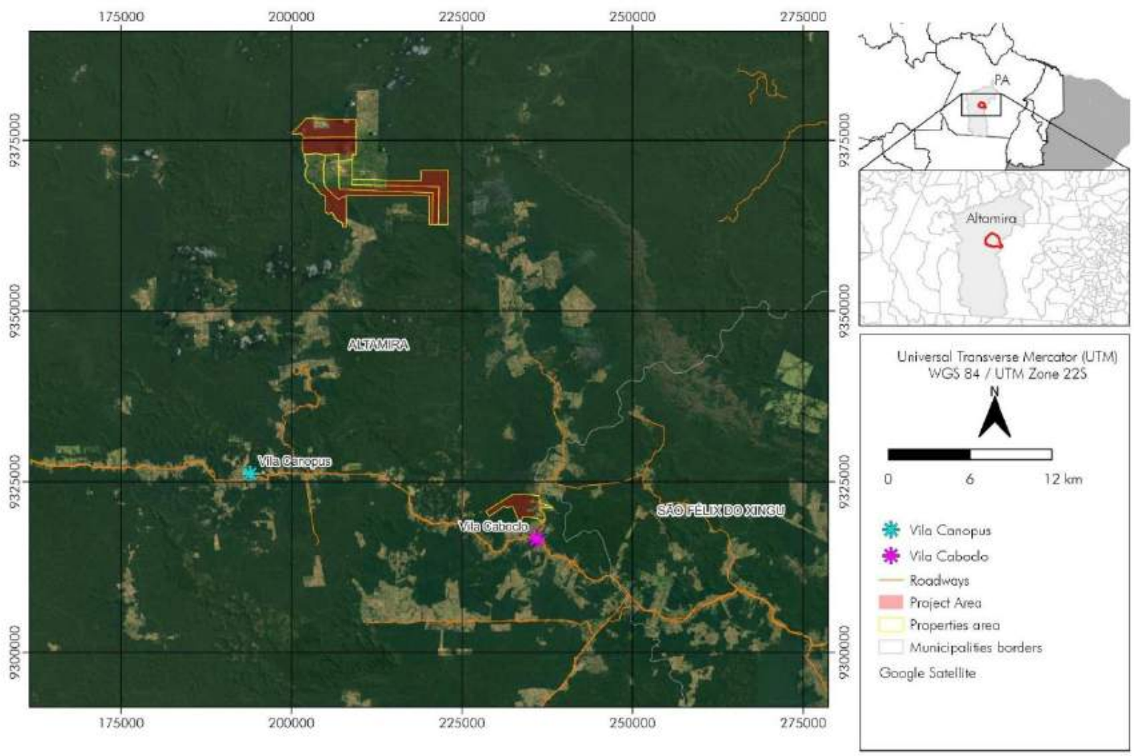

Figure 1.7. Location of the Caboclo Village and Canopus Village communities in relation to the Project Areas.

1.13.4 Ecosystem type

The Project region is located in the ecosystem of the Brazilian Amazon. According to the IBGE environmental database (Bdia) (IBGE, 2022a), the region covered by this project includes three of the main phytophysiognomies found in the Amazon rainforest, where most of the territory (> 85%) is covered by forest. rainforest canopy and forest transition, and 8% of dense rainforest canopy.

The areas with dense-canopy rainforest are characterized by dense vegetation in all strata (tree, shrub, herbaceous, and lianas) (SFB, 2020). In the most preserved areas of Dense-canopy rainforest, where physical conditions allow, the height of vegetation increases, and there is presence of epiphytes. In these areas, natural disturbances can be observed, which occur due to the natural death of trees or events such as lightning, strong winds, and other reasons (IBGE, 2012).

The Open-canopy rainforest is a variation of the Dense-canopy Forest, being a more open forest formation, where combinations of particular species in associations are commonly observed (SFB, 2020). The municipality is part of the Amazon Biome, presenting an extensive territorial area covered by dense equatorial forest with large trees and emerging vegetation. Its fauna follows the biological variety of the flora, presenting itself as rich and diversified (SEMAT, 2012). In addition to the Amazon rainforest, the municipality has other features such as secondary vegetation and crops such as sugarcane, cocoa, as well as subsistence crops (SEMAT, 2012).

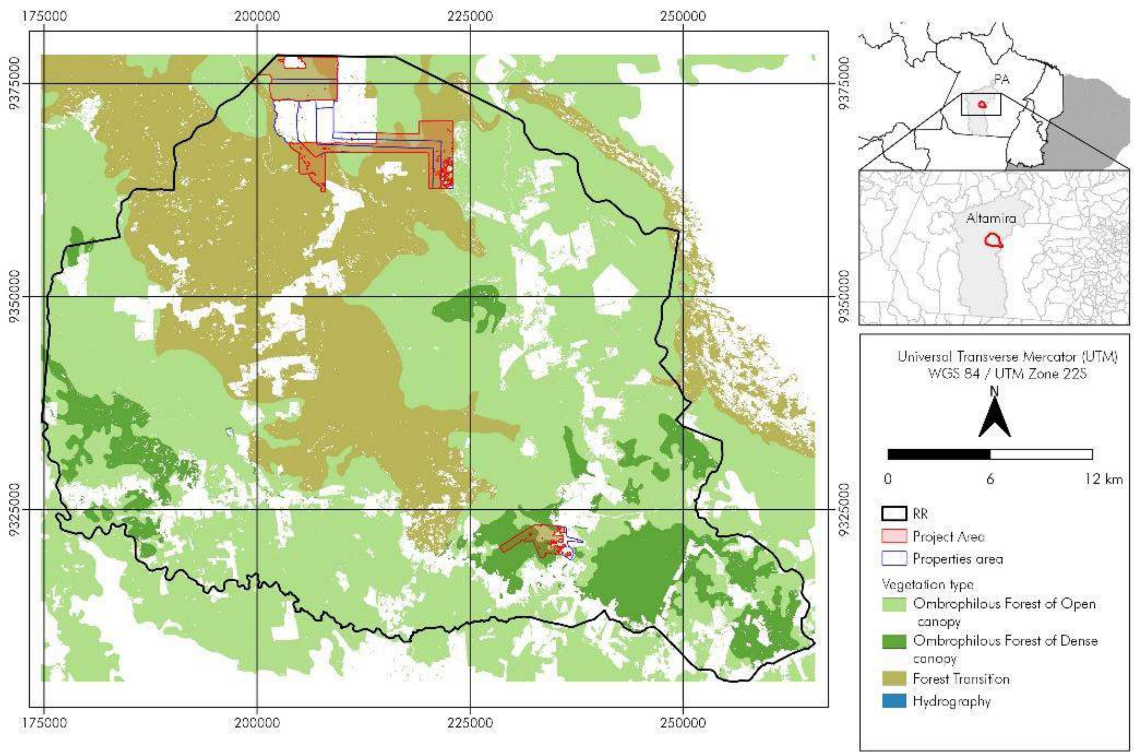

Figure 1.8. Vegetation type in Triunfo do Xingu Grouped Redd+ Project region.

Climate

The project region is classified as Tropical Climate – Am and Aw category - in the Köppen climate classification (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006). The municipality is going through a climate transition, although most of the territory (97%) presenting the Aw category (Figure 1.9). The average rainfall for the Af climate is around 2200 mm, higher than the average rainfall for the Am climate, around 2100 mm, with an average temperature of 26°C. The rainiest months are from December to May (Hoffmann, Dallacort, Carvalho, Yamashita, & Barbieri, 2018). The database to define the climates of the region, according to the Kopper data classification system used, was a vector database published by Alvares, Stape, Sentelhas, Gonçalves, and Sparovek (2013).

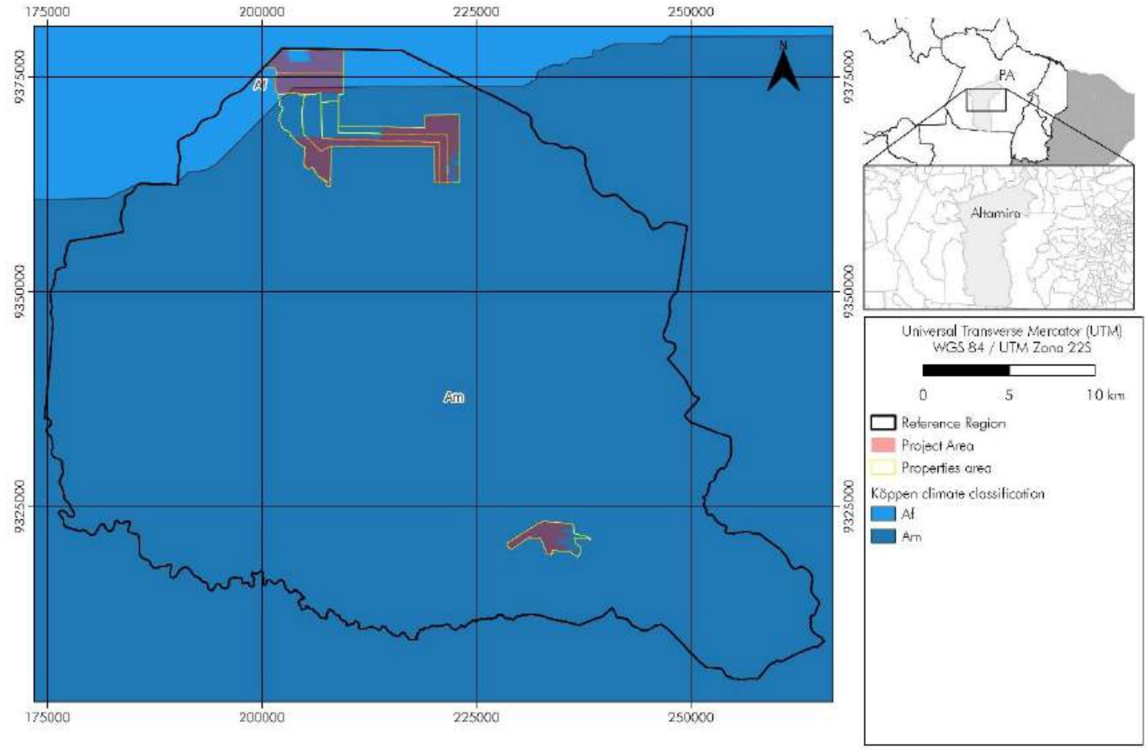

Figure 1.9: Predominant climate, according Köppen climate classification, in Triunfo do Xingu Grouped Redd+ Project region.

Hydrology

The reference region is located in the Xingú River Basin (IBGE, 2021c), and within the RR it has three sub-basins called the Iriri River Basin, the Pardo River Basin, and the *"Igarapé do Pontal"* Basin. The properties are located in the Iririri Basin, and have a small overlap with the *"Igarapé do Pontal"* Basin. Also represented in the Figure 1.10 are the main hydrographs (ANA, 2012) such as the Igarapé da Bala River, as well as its headwaters and smaller rivers (FBDS, 2022).

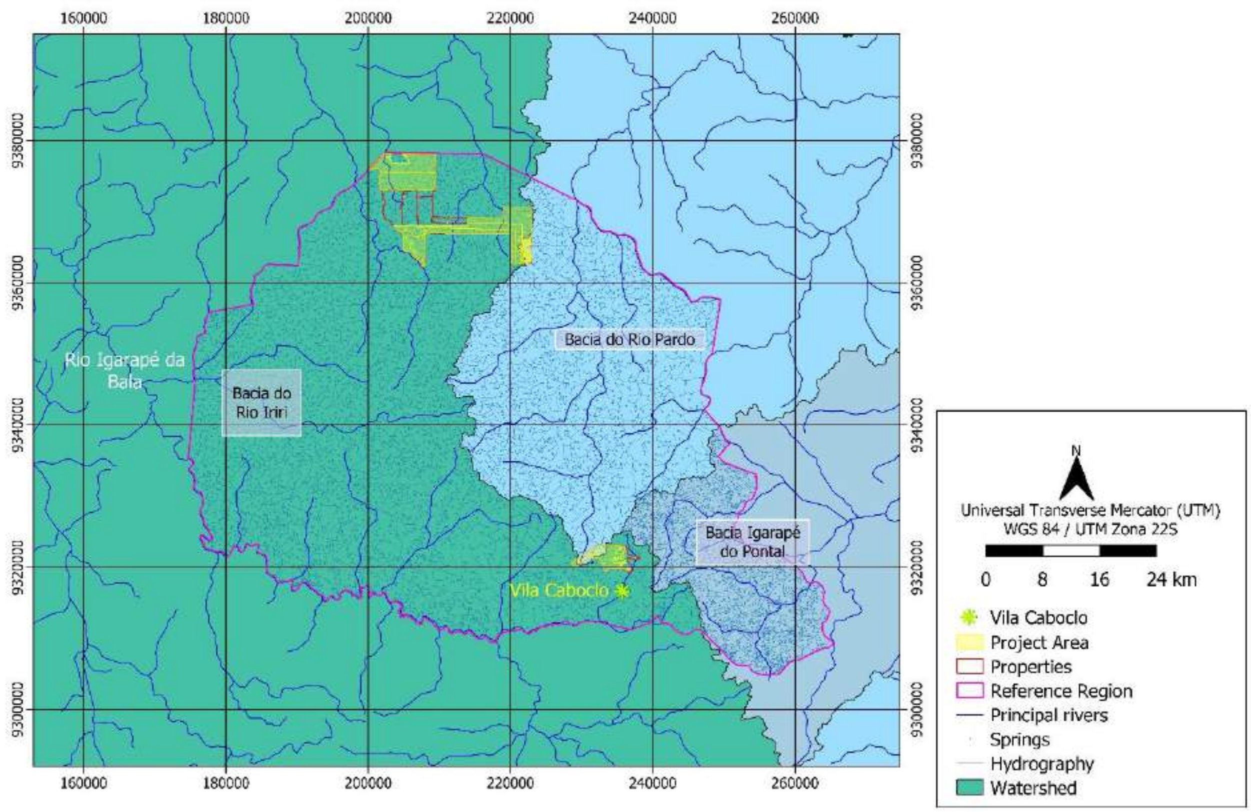

Figure 1.10 TdX Reference region and project area Hydrology

Geology, Topography and Soils

Regarding geology, the municipality of Altamira is located on the tertiary and quaternary Amazonian plateau. In the valleys of the Xingu and Tapajós rivers, the outcrops found are from the Devonian period, while the Eo-Devonian are found on display in the Xingu riverbed, and in the Igarapé das Panelas. Downstream of the waterfalls between Tubarão and Igarapé Canoé belong to the Mesodevonian period, and to the northeast of Altamira there is a large flat and slightly undulating area whose formation is due to the evolution process of sediments from the Tertiary, Pliocene period (Falesi et al., 1967).

The Project region is formed by Argisols and Neosols. In particular, the relief is one of the factors in the formation of soils in Altamira. In flat reliefs, the Argisol predominates, represented by the Yellow Latosol with medium and clayey textures and, in the wavy areas, there is an occurrence of the Red-Yellow Latosol – medium and clayey textures – and Red-Yellow Podzolic – medium and clayey textures (Figure 1.11) (Falesi et al., 1967).

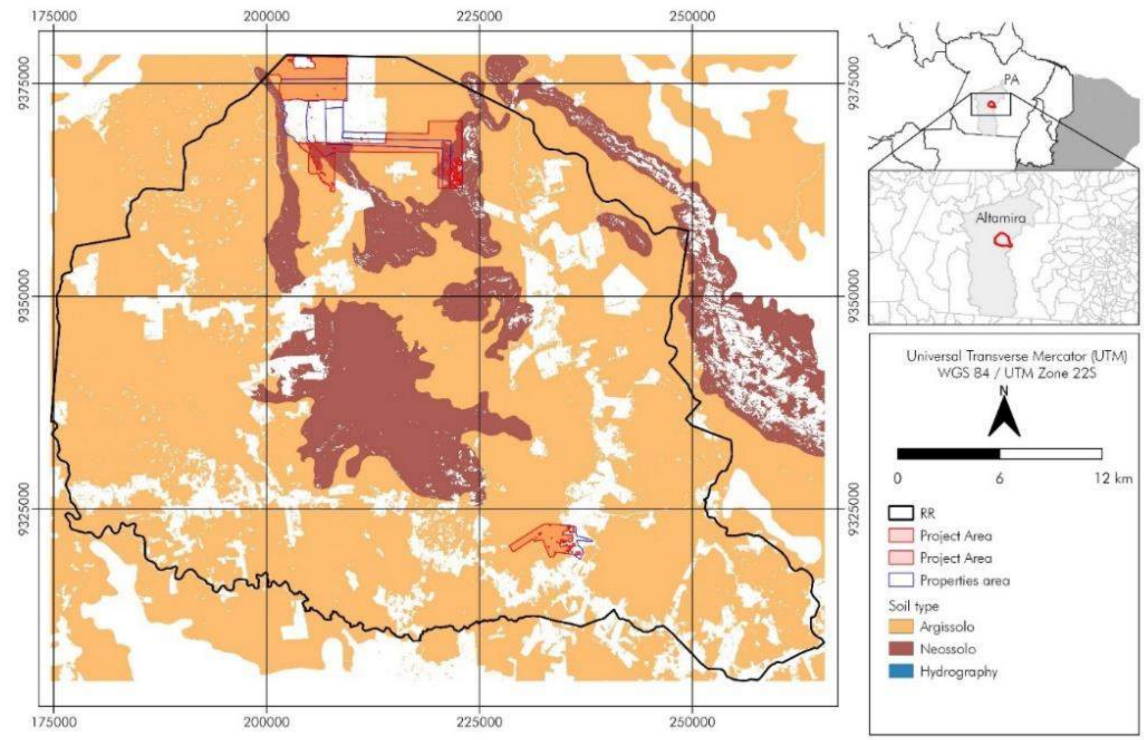

Figure 1.11: Soil type in Triunfo do Xingu Grouped Redd+ Project region.

About 75% of the project area has a slope <15%, although slopes >15% are found in 25% of the areas, mainly to the east of the properties, and the altitude in the project area ranges from 169 to 500 meters. To obtain elevation and slope information, a mosaic of digital elevation models, provided by NASA, with a spatial resolution of 30 meters (Farr et al., 2007). No areas above 500 meters were found within the project area (Figure 1.12). Topography is often related to physical and chemical soil variations that are often reflected by vegetation.

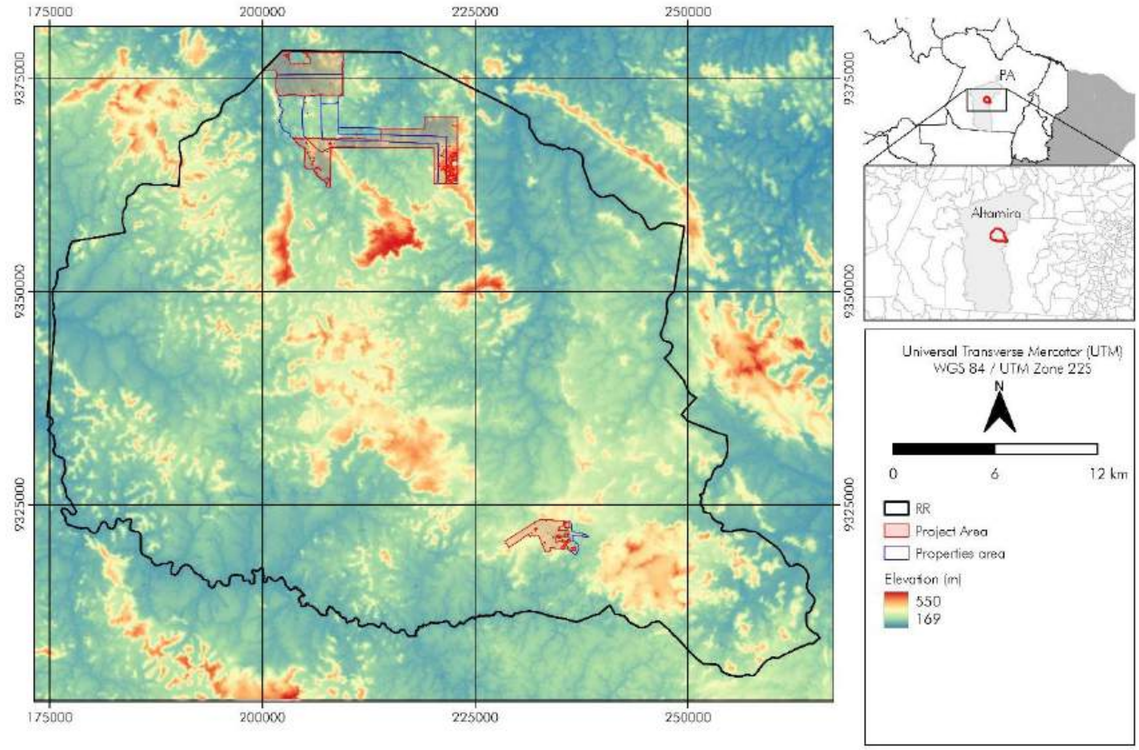

Figure 1.12: Map of elevation, in meters, in Triunfo do Xingu Grouped Redd+ Project region.

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

Federal Laws and Regulatory Frameworks

At a federal level, one most important legislation is Law Nº 12.651 of 25/05/2012 that created the newest Brazilian Forest Code. There are some important articles and chapters to be considered that are replicated below.

"Article 3. For the effects of this law, the following definitions apply:

> I – Legal Amazon: the States of Acre, Pará, Amazonas, Roraima, Rondônia, Amapá and Mato Grosso, and the regions located to the North of parallel 13º S, in States of Tocantins and Goiás, and to the West of meridian 44º W, of the State of Maranhão (Figure 1.13).
>
> II - Permanent preservation area (APP): protected areas covered or not by native vegetation, with the environmental function of preserving water resources, landscape, geological stability, biodiversity, gene flow of plants and animals, protect the soil and ensure the well-being of human populations.
>
> III - Legal Reserve area located within a rural property or ownership, demarcated according to article 12, with the function of ensuring a sustainable economic use of natural resources of rural property, assist the conservation and rehabilitation of ecological processes and to promote the conservation of biodiversity, as well as shelter and protection of wildlife and native flora.

(...)

Article 12. All property must maintain rural area with native vegetation cover, as a legal reserve, without prejudice to the application of the rules on the Permanent Preservation Areas, subject to the following minimum percentages in relation to the area of the property, except as specified in art. 68 of this Act.:

I – Located in the Legal Amazon:

80% (eighty percent), in the property situated in forest area;

35% (thirty five percent), in the property situated in cerrado;

20% (twenty percent), in the property situated in the area of general fields;

II – Located in other regions of the country: 20% (twenty percent).

(...)

Article 29. Creates the Rural Environmental Registry (Cadastro Ambiental Rural – CAR) within the scope of the National System Information on the Environment – SINIMA as a public electronic record on a national level, mandatory for all rural properties, to integrate environmental information of rural properties and possessions, composing a database for control, monitoring, environmental and economic planning and combating deforestation."

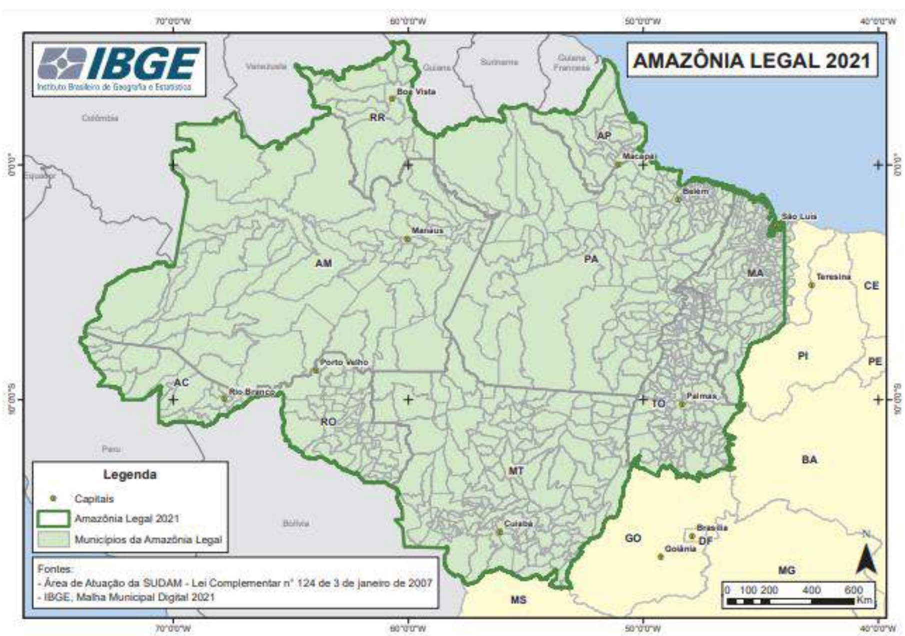

Figure 1.13. Brazilian Legal Amazon States: Acre (AC), Amapá (AP), Amazonas (AM), Maranhão (MA), Mato Grosso (MT), Pará (PA), Rondônia (RO), Roraima (RR), Tocantins (TO) (ancient north of Goiás).

The legislation also says that he Legal Reserve (LR) must be registered in property deed in the Real Estate Registry Office, its location must be publicly known, and future landowners must know where it is located, its boundaries and frontiers. The LR can be located anywhere inside a rural estate. Once allocated, the LR may not be changed even in cases of real estate transfer, land dismembering or area rectification.

The LR allocation is a prerequisite to obtaining permission to exploitation of the native vegetation existing inside the rural estate. In compliance with Brazilian Forest Code, the farms have officially allocated even more 80% of its total area as LR, once the only economic activity that takes place in the property is the forest management, which conservates the vegetation characteristics in the region.

In the Reference Area, although 80% of native vegetation in land properties must be preserved as LR, there is a general non-compliance with Brazilian Forest Code, as 33.19% of the original forest has already been deforested and is occupied by anthropic activities (i.e. there is a deficit of 13.19% of native forest that should not have been suppressed in the Reference Area). Despite the legal provisions intended to preserve at least 80% of the Amazon Forest coverage, lack of law enforcement by local authorities along with public policies seeking to increase commodities production and encourage land use for agricultural, bio energy and cattle breeding purposes created a scenario of almost complete disregard of the mandatory provisions of the Forest Code. High rates of criminality associated with land disputes usually jeopardize efforts concerning law enforcement improvement (HRW, 2019). In addition to that, to cover vast distances of areas with low demographic density makes tracking of illegal activities and land surveillance very difficult for the authorities.

Even though the Brazilian Forest Code being the more specific environmental legislation in a national level regarding the use of land in the legal Amazon, other legislations are also necessary. Rural activities have several perspectives that are not resumed only by the environmental one. Here all other legislations consulted that guided and are assisted by the due diligence process of this project:

- Brazilian Federal Constitution of 1988 (Brasil, 1988).
- Brazilian Imperial Law, Law 601/1850 (Brasil, 1850).
- Rural Land Statute, Law 4,504/1964 (Brasil, 1964).
- Law of Public Records, Law 6,015/1973 (Brasil, 1973).
- Law of Civil Action, Law 7,347/1985 (Brasil, 1985).
- Law of Rural Property Tax, Law 9,393/1996 (Brasil, 1986).
- Federal Environmental Crimes Law, Law 9,605/1998 (Brasil, 1998).
- Brazilian Civil Code, Law 10,406/2002 (Brasil, 2002b).

Together, all those laws can be complex for those who are not familiar with them. But the main objective of them, in a simpler way, is to demand from the landowner: (i) proof of their legal right to have and possess their land for different government agencies, (ii) guarantee that financially all taxes are being paid, (iii) there are no legal or civil lawsuits that could compromise the landowner.

State Laws and Regulatory Frameworks

ITERPA is the Pará state agency responsible to coordinate the rural land regularization process. By Law Nº 8,878 of 2019 (Pará/Brasil, 2019), the institute provides the necessary requirements to all those who wish to be legal landowners of the land they possess.

Table 1.11 shows the entire Brazilian legislation that needs to be attended by the project and the complete documentation necessary to the TdX project be in accordance with current legislation framework and the attendance of each one of theselaws is available attached[12].

Table 1.11. List with all laws that need to be attended by to guarantee the project compliance.

Laws/Regulations	Comments
Brazilian Civil Code, Law 10,406/2002 (Brasil, 2002b). Law of Public Records, Law 6,015/1973 (Brasil, 1973).	Updated Real Estate Records indicating liens, debt, or court lawsuits to the property regarding the past 20 years. It proves the regularity of the property and if it is free and clear of any liens and encumbrances.
Brazilian Civil Code, Law 10,406/2002 (Brasil, 2002b). Law of Public Records, Law 6,015/1973 (Brasil, 1973). Brazilian Federal Constitution of 1988 (Brasil, 1988). Brazilian Imperial Law, Law 601/1850 (Brasil, 1850)	Certificate issued by the Real Estate Registry Office with the complete chain of domain and ins transfer from public domain to private domain. Since all the rural land in Brazil was a state owned asset and must fulfill with specific requirement to be transferred to the private domain, the chain of domain is necessary to verify the regularity of the land.
Rural Land Statute, Law 4,504/1964 (Brasil, 1964)	The Rural Property Registry (CCIR) is important to attest that the property is regular to the National Institute of Colonization and Agrarian Reform (INCRA).
Law of Public Records, Law 6,015/1973 (Brasil, 1973)	According to the Law of Public Records, to validate the property transfer, rural properties with more than 100 hectares must have a geodesic survey approved by INCRA.
Law of Rural Property Tax, Law 9,393/1986 (Brasil, 1986)	The Rural Property Tax Filings (DITR) must be delivered annually by every rural property owner. It is important to verify the regularity before tax authorities.
Brazilian Forest Code, Law 12,651/2012 (Brasil, 2012)	The CAR is a legal obligation that provides properties' environmental information related to the existence of environmental protected areas, place of the legal reserve, as well as the existence of native vegetation that exceeds the minimum required for legal reserve purposes.

[12] Annex: 230314_TdX Proof of Title.zip

Laws/Regulations	Comments
Federal Environmental Crimes Law, Law 9,605/1998 (Brasil, 1998).	In accordance with the Federal Environmental Crimes Law, certificates issued by the competent state and federal Environmental Authority, which in this case is SEMAS-PA and IBAMA, respectively, are necessary to provides information of existing environmental assessment, penalty and procedures.
Law of Civil Action, Law 7,347/1985 (Brasil, 1985). Brazilian Civil Code, Law 10,406/2002 (Brasil, 2002b).	To the Law of Civil Action it is important to verify the existence of civil action related to the property issued by the Federal and State Prosecutors Office. By its time, the Brazilian Civil Code demands certificates issued by the State Court of Justice of the property(s) and the domicile of the owner(s), covering a period of 10 years.

Commitment of the landowners

As an additional safeguard, the owners of the areas have expressly committed to respecting labor legislation and ethical standards. These obligations are expressed in the project contracts, and if they are not met, penalties may be applied to the owners[13,14].

1.15 Participation under Other GHG Programs

1.15.1 Projects Registered (or seeking registration) under Other GHG Program(s)

This project has not been registered and is not seeking registration under any other GHG Programs.

1.15.2 Projects Rejected by Other GHG Programs

Not applicable. This project is not requesting registration in any other GHG Programs nor has the project been rejected by any other GHG programs.

1.16 Other Forms of Credit

1.16.1 Emissions Trading Programs and Other Binding Limits

The project does not reduce the GHG emissions from activities that are included in any emissions trading program or any other mechanism that includes GHG allowance trading. This project and its activities of reducing emissions from the AUDD category aims to generate credits only under the Verra’s VCS program.

[13] Anexx: 221014_Systemica-Didácio contract.pdf

[14] Anexx: 221014_Systemica-Sefer contract.pdf

1.16.2 Other Forms of Environmental Credit

The project did not seek or received any other form of GHG-related credit. This statement includes renewable energy certificates. This project description being submitted to Verra is the first initiative in direction to emit credits for reducing the GHG emissions.

1.17 Sustainable Development Contributions

The TdX Project aims to achieve specifics Sustainable Development Goals (SDG). The investment of part of the revenues generated by the sales of VCUs will be carried out to implement positive actions for the local community and biodiversity also considering the SDG adaption to the Brazilian reality (IPEA, 2018).

We seek with these investments to contribute the following goals (but not limited to the described) in Table 1.12. Project activities from SDGs 4 and 8 are already in execution as described trough the section 2. The project existence by itself would already contribute with SDGs 13 and 15, project monitoring activities that are going to be implemented are detailed in Section 5.

Table 1.12 TdX Sustainable Development Contributions

SDG	National Goal	Project Activity
4	4.4, for promoting the relevant skills, including technical and professional skills, for employment, decent work, and entrepreneurship. 4.7, because the project will promote inclusive education for sustainable development.	Development of Environmental Education projects aimed at strengthening and empowering communities to take sustainable attitudes and develop productive alternatives that ensure the preservation of forest and local biodiversity, and the deconstruction of the custom of using fire for the cleaning/treatment of arable areas.
8	8.3, for promoting activities that lead to decent job creation. 8.6, by identifying the culture and local products potentialities.	Stakeholder consultation to identify the community priorities, look for decent job creation, and promote sustainable tourism, culture, and local products.
13	13.2, by avoiding unplanned deforestation in the project area 13.3, by raising climate change awareness	The project is taking urgent action to combat climate change and its impacts, by reducing the GHG emission of 2,396,305.31 tCO_2e until 2028, as well as raising the community's awareness of the topic.
15	15.1, because the conservation of the ecosystem is guaranteed	The project consists of the implementation of a REDD+ project in the Amazon rainforest biome, reducing the potential drivers of unplanned deforestation in the project area.

SDG	National Goal	Project Activity
	15.5, because conserving the ecosystem is helping to prevent the loss of biodiversity. 15.5, as by halting deforestation measures are being taken to reduce habitat degradation and biodiversity loss 15.7, because protecting this project area and keeping it under surveillance would be contributing to the control of illegal wildlife hunting (local plates).	Then, it is going to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss.

1.18 Additional Information Relevant to the Project

Leakage Management

The main leakage management activities are described in Section 1.11. Description of the Project Actiity, especially in the items of Leakage Control.

Commercially Sensitive Information

Information supporting the internal cost assumptions were considered as commercially sensitive information, such information can be found in the additionality and non-permanence internal risk sections, and will be available to the auditor at the time of the project validation. No commercially sensitive information has been excluded from the rest of the public version of the Project Description. Through the entire section 1 of the Project Description document, all relevant and necessary information regarding the project proponent and the conditions prior to the project implementation has been made available. The same affirmation is valid for rest of the entire PD, as in the developing of the safeguards and baseline topics.

Further Information

No further information to disclose.

2 SAFEGUARDS

2.1 No Net Harm

The municipality of Altamira has an area of 159,533.306 km² and an estimated population of 117,320 inhabitants, according to IBGE data (IBGE, 2022c). However, the administrative center of the municipality is many kilometers away from the project area and its vicinity, and this distance is reflected in the lack of State control, which does not provide public policies and social assistance. This scenario contributes to the few actions of infrastructure and social control, which is managed by the large landowners and parallel powers built by groups of the rural elite and representatives of illegal activities such as mining and land grabbing.

Altamira has a low population density of 0.62 inhabitants/km², an index below the Brazilian average of 22.43 inhabitants/km², and the north region average of 4.12 inhabitants/km² (IBGE, 2022c). This low settlement is related to extensive regions of demographic void. The project's territory of interest is inserted in the Amazon biome, with emphasis on important areas of Environmental Preservation located in the central region of Altamira, namely the APA Triunfo do Xingu, the Serra do Pardo National Park, the Terra do Meio Ecological Station, and the Iriri State Forest.

This scenario is even more aggravating if we consider that high deforestation numbers result in a proportional increase in the number of fires. In August 2022, in the period between 01 and 31 was detected an alarming volume of heat foci, with a record of 47,507 outbreaks in the Brazilian Territory, of which 26.3% were registered in the state of Pará, which has been leading, along with the Amazonas and Mato Grosso, the process of degradation of the Amazon biome in the country in the last three years (INPE, 2022b).

Given this scenario of advancement in the process of degradation of the Amazon biome, initiatives that focus on environmental preservation, such as the adoption of carbon credits, reduction of vegetal suppression, among others of a sustainable nature, need to be implemented with the objective of guaranteeing the maintenance of the standing forest, the protection of biodiversity, concomitantly with the adoption of measures that ensure the improvement of the quality of life of the communities in interface with the forest areas. Therefore, the pressure of deforestation in the State of Pará can be understood as a result, mainly, of the illegal occupation of private lands, using for this purpose logging, illegal mining, and the burning of forests to make pasture for cattle (Escada et al., 2005). Thus, this pressure is related to the destruction of significant portions of the forest in the region, from the following aspects: (a) conversion of forested areas into areas for agriculture and cattle-raising for the purposes of land ownership or not; (b) unsustainable timber extraction; and (c) land clearing by fire (d) illegality of land tenure and ownership; (e) lack of state governance and law enforcement. All these activities that lead to deforestation can be found in the Brazilian Amazon and specifically in the State of Pará.

The study region of the Triunfo do Xingu Grouped REDD+ Project is surrounded by the Terra do Meio conservation unit. Created in 2005, the Terra do Meio Ecological Station (ESEC) has the mission of preserving nature, allowing only the indirect use of natural resources of about 3,373,110 hectares that make up the reserve. The Terra do Meio ESEC is managed by the Chico Mendes Institute for Biodiversity Conservation, is located in the eastern Amazon, and is home to several endangered species of birds, amphibians, fish, mammals, and reptiles (MMA, 2022).

The region suffers from a great volume of criminal activities and is at the epicenter of the impact of large enterprises, such as the Belo Monte dam and the Belo Sun mining project. With the weakening of environmental policies, observed in the last four years, and the impact from the construction and implementation of these structures, part of the people who had been removed from this region have returned to occupy and cause pressure on protected territories. In addition, land grabbers continue to appropriate new areas and create new areas of deforestation.

The region is noted for having the highest rates of deforestation and fires in the country. In 2022, the State of Pará presented one of the highest incidence of fires in Brazil, with 26,190 registered fires in August, the driest month in the Amazon biome. Between August 1, 2022 and October 5, 2022, Pará was responsible for 33.9% of all the fires recorded in the Amazon biome (INPE, 2022b). Compared to other conservation units, the Triunfo do Xingu Environmental Protection Area presents the highest numbers of fires and suffers pressure mainly due to the conversion of forest to pasture (IBGE, 2021a).

There is also pressure from the increase in the number of cattle (IBGE, 2021a) both in the municipality of Altamira and São Felix do Xingu. In this case, fire is used both to clear and renew pastures and to expand areas and open new pastures for cattle. Regarding the Triunfo do Xingu Grouped REDD+ project, the situation of pressure for deforestation and increase in the number of fires was observed by the field research team, who reported the presence of hotspots and portions of vegetation suppressed by fire all along the road connecting the municipality of São Félix do Xingu to the properties participating in the project.[15]

The grouped project area is controlled of two landowners: (i) Rafael Sefer and (ii) Didácio Barros. Santa Maria Pecuária e Agronegócio LTDA is the company that carries out livestock activities on Rafael Sefer's proprieties: (i) Belcon, (ii) Santa Marta, (iii) Retiro Encantado (iv) Vó Lina, (v) Patacho and (vi) Campo Lindo farms. Thus, "Santa Maria farm" is the usual name used by the surrounding communities and employees to refer to Rafael Sefer's properties set. "Nossa Senhora Aparecida" is the name of the property owned by Didácio Milhomens Barros. The Sefer's properties and Nossa Senhora Aparecida farm have tried to go against this worrisome reality and the trend of increasing environmental degradation that has been observed in the region where they are located. Each one of them has its own history of setting up cultivation and pasture areas, and of land legalization, however, the owners have shown themselves to be aware of the deforestation situation in the region and that, each one in its local area of influence, to be a management model and serve as an example of sustainable economic development, capable of mobilizing other players towards the promotion and maintenance of the standing forest.

Thus, despite being in areas under pressure from land grabbing, deforestation, fires and land invasions, no illegal occupations were observed in the areas of the abovementioned farms, nor were there any lawsuits or ongoing processes related to land ownership. Thus, it was not necessary to carry out any mitigation procedures related to repossession suits, relocation of populations, or any other litigious process. In any case, to avoid the incidence of these types of conflicts in the project properties, it is necessary to implement a monitoring system capable of preventing these conflicts that surround the protected forest areas, thus avoiding damage to the portions of vegetation and biodiversity that remain intact.

[15] Annex: 221014_Burned Areas.pdf

2.1.1 Potential negative impacts mapped for stakeholders and mitigations

The territory surrounding the borders of project properties consists of an area of demographic emptiness, and does not present, in the satellite image studies, in the primary data surveys carried out throughout the fieldwork, and in secondary data through desk research, the occurrence of Indigenous Lands, registered *Quilombola* Communities, Settlement Projects, and Traditional Communities (riparian, extractivism, fishing or gathering communities).[16,17,18]

No evidence of the presence of rubber tappers, extractivism, *piassaba* workers, or fishermen was found in the region. A specific survey of the rural communities in the region was carried out, based on secondary data provided by technicians from ADEPARÁ - the Agricultural Defense Agency of the State of Pará (IBGE, 2022b). The satellite-image measured straight line distances between the project properties and the communities are represented in Table 2.1.

Table 2.1. Straight line distance between the community settlements and the project properties.

Community	Straight line distance to Rafael Sefer's properties (km)	Straight line distance to Didácio Milhomens's property (km)
Caboclo Village	48.8	4
Canopus Village	45.3	35.9
Fumaça Village	61.7	16.5
Pontalina Village	69.0	26.5
Pontal Village	70.9	30.5
Crentes-Village	72.9	32.8
Central Village	83.4	43.2
Primavera Village	106.1	75.7

The community of Caboclo Village is a rural village, where most of the residents live on subsistence farming and rural services, with part of the local labor being allocated during harvest periods or in jobs linked to the rural properties in the region. The village has about 90 inhabitants, according to information provided by the Novo Pacto Municipal School, located in Caboclo village. The school serves 48 children and young people from the region, aged between 5 and 16, and offers 1st to 9th grades of Brazilian elementary school. The village has a health center, but no leisure, cultural and sports equipment was observed in use in the locality.

Caboclo Village received its popular name because of the Caboclo stream, a tributary of the Xingu River, although its real name, Irinópolis Village, is practically unknown by the community itself. In August 2022, it was informed through oral reports that the community has about 25 residences, 21 of which belong to

[16] Annex: 221014_ Socioeconomics_QuilombolaCommunities_rev.pdf

[17] Annex: 221014_ Socioeconomics_SettlementProjects_rev.pdf

[18] Annex: 221014_ Socioeconomics_IndigenousLands_rev.pdf

permanent residents, while 4 belong to temporary members, who have a house in the village but live at another residential address, usually in the neighboring regions. Due to the proximity of one of the project's properties (Nossa Senhora Aparecida farm), Caboclo Village will be the priority target for the implementation of the planned community activities.

Although *Fumaça* Village is 16.5 Km from the headquarters of *Nossa Senhora Aparecida* farm, the processes of diagnosis and interview of the community has not been carried out. This is due to the fact that the community is not in the database of IBGE (2010) and it is very difficult to be identified through satellite images. Therefore, *Fumaça* Village was not identified during the technical and methodological planning prior to our first field research. *Fumaça* Village was only identified during interviews with ADEPARÁ technicians located in the municipality of São Félix do Xingu, who provided the geographic points of the villages and neighborhoods in the region, from which a KML file was generated..[19] This village is composed of a small cluster of houses arranged along a stretch of unpaved road and the access by land is difficult, due to the poor conditions of the roads and bridges. *Fumaça* Village data is only found ADEPARÁ's internal documents. In fact, the data provided by ADEPARÁ technicians are for internal use by the department for mapping purposes of properties and herds, regarding the control of Foot and Mouth Disease (FMD).

During the field visit period for the presentation of the project and the REDD+ capacity building activity, a socio-environmental diagnosis was carried out with the local community of Caboclo Village to assess the impacts of the project and their perception of them.[20] At this moment, communication channels were opened and information about the project activities was made available. The cell phone numbers of local stakeholders were also collected to create a local stakeholder listand later, a conversation group was created through the WhatsApp application between the members of Vila Caboclo and Systemica, as shown in section 2.5 of this document. The list of stakeholders,[22] as well as the telephone contacts, can be found in the attached spreadsheet, which also presents data from the survey of institutional agents that operate in the region, whether through environmental agencies, municipal secretariats, universities, unions, non-governmental organizations and other institutions of interest and potential partners of the project.[23]

Regarding the execution of the project and the interface of the farm activities with the local stakeholders related to the project, no negative impacts were detected, of direct or indirect order to these populations. In addition, the majority of actors interviewed reported that they have a good relationship with the farms or are indifferent to it.

However, some potential risks which relate to the local socio-economic and environmental scenario have been identified:

[19] Annex: 221014_Social_diagnosis.kml

[20] Annex: 230515_REDD+_Capacity_Building.zip

[22] Annex: 230314_Stakeholder_list.xlsx

[23] Annex: 221014_Stakeholder Consultation-Caboclo Village-Questionnaires.pdf

- The production of pasture areas for cattle-raising, the predominant activity in the region, is carried out through deforestation with the use of illegal fires, which in most cases are not properly handled, resulting in risks of uncontrolled spreading, endangering people, forest, cattle, and other assets.

In order to mitigate the spread of fire in the project areas, the landowners are committed to maintaining firebreaks on the project properties. Firebreaks are very effective technique commonly employed in the region to contain and prevent fires, and are largely recommended by the fire department and IBAMA (2009). Regarding the implementation and maintenance of firebreaks, the fire department has developed technical material that is easy to access on techniques, dimensions and practical notions for the construction of firebreaks (PMESP, 2006).

The mitigation of possible conflicts, resulting from illegal occupation of the project area by land grabbers or from the invasion of the project properties, will be carried out through the following activities:

1. Identification of strategic points to establish surveillance checkpoints prioritizing zones bordering areas with high probability of invasion, i.e., areas that have historically presented this type of event.
2. Physical markers made of solid materials such as wood and concrete will be erected along the perimeter of the properties, each featuring a georeferenced marking that indicates its precise location at properties' border.
3. Establishment of the monthly frequency for the surveillance rounds.
4. Contact with the Caboclo Vallage community in order to developing environmental education, continuing the REDD+ capacity building activities already carried out.[24]
5. Identification of neighboring landowners in order to prevent leakage.

2.2 Local Stakeholder Consultation

The Local Stakeholders were identified based on section 3.18.12 of the VCS Standard v4.4. Therefore, the groups that will be impacted by the project were included as local stakeholders, as presented in the list of stakeholders in XLS spreadsheet[25]. They include the Caboclo Village community (community stakeholder), as it is the closest community to the project, where the REDD+ capacity building activities were applied, and also depend on water resources partly provided within the project areas, as it is further detailed in the paragraphs below in this section; relevant institutions (institutional stakeholders), as the project performs activities synergistic to its objectives; and the administrators of the project farms (other stakeholders), as they will participate in local management and monitoring activities.

The stakeholder consultation was done through direct communication with the Caboclo Village community (community stakeholder), relevant institutions (institutional stakeholders) and the farms administrators (other stakeholders), during the months of August and September 2022. The families of the rural community of *Caboclo* Village were visited by a team that carried out the social diagnosis and

[24] Annex: 230515_REDD+_Capacity_Building.zip

[25] Annex: 230314_Stakeholder_list.xlsx

distributed the pamphlets containing the contact phone number and e-mail of the project[26,27,28]. During this visit, a semi-structured questionnaire was applied, with the purpose of providing the necessary information to produce a socio-environmental diagnosis of the residents and to collect information about the potential impacts that the project could have in the community[29,30] was sent to other interested parties, such as public and private institutions, and this communication channel will serve as support for sending a summary of the project, and information about the auditing visits.

Posters were placed in strategic locations in the areas adjacent to the project, informing about the most relevant information, later, warning posters were placed about the validation audit and in the future, warning posters about audit visits will always be placed.[31,32].

From the information collected, it is understood that there are no direct or indirect risks to local stakeholders associated with project activities, since the owners do not allow any kind of extractivism or permanence within the project areas, therefore, there are no communities occupying the internal part of the project area and the only identified community dependence is the use of the caboclo stream for fishing and swimming, considering that part of its water regulation and water quality is provided through a preserved catchment located in part of the project area, as shown in Figure 2.1. As the project activities have a preservation objective, the provision of these ecosystem services will not be harmed in any way, in fact, it will only be more assured. Well known benefits of the maintenance of forests are related to supporting and regulating ecosystem services, such as air quality, climate, water, protection against erosion and degradation processes, soil formation and regeneration, pollination, biological regulation, nutrients, life-maintenance cycles, and protection of the gene pool (Loft, 2011). Among other additional positive impacts expected by the community are project activities associated with the municipal school Novo Pacto and the local health center, and job and income generation opportunities, specially targeting the improvement of opportunities for women and young people. These activities have a close impact on the sustainable development goals for 2030, defined by the United Nations, in the fight against hunger and poverty eradication, improving the quality of education, access to health care, employability of the population, and economic growth, reinforcing gender and equality issues, in addition to combating climate change and protecting biodiversity.

[26] Annex: 221014_CV - Caroline Césari de Oliveira - Oct2022.pdf

[27] Annex: 221014_CV - Marco Aurélio - Aug2022.pdf

[28] Annex: 221018_Pamphlet.pdf

[29] Annex: 221014_Stakeholder Consultation-Caboclo Village-Questionnaires.pdf

[30] Annex: 230309_Stakeholder_consultation.zip

[31] Annex: 221014_Posters_community.pdf

[32] Annex: 230513_ Audit_Warning_Posters.pdf

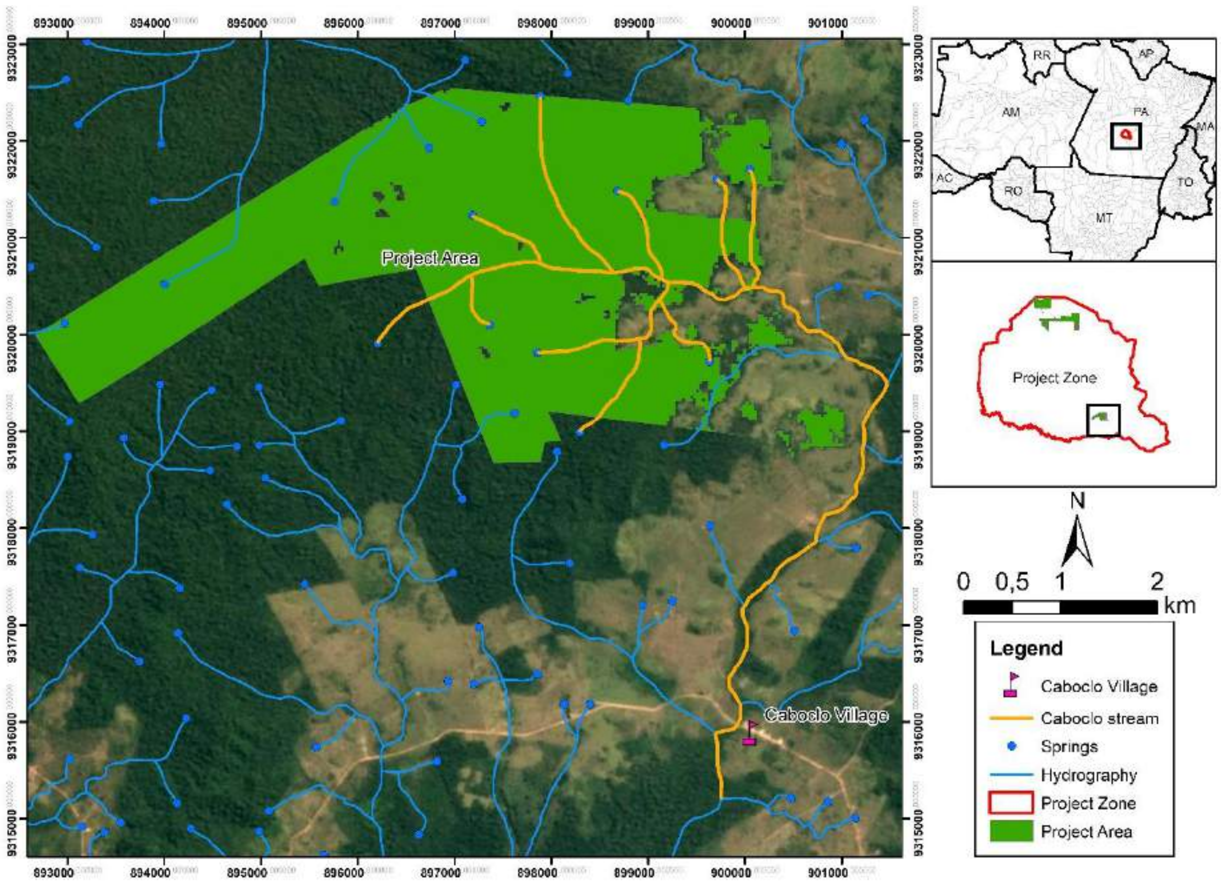

Figure 2.1.Map of the Caboclo stream, highlighting one of its catchments located within the project area.

The fieldwork was a relevant part of the diagnostic process of the social, environmental, and economic conditions of the communities and actors of interest of the project. It was carried out by a research team, composed of professionals specialized in community approaches and engagement, during the period from 28-08-2022 to 08-09-2022, for a total of 12 days of field research. The main objectives achieved through the fieldwork are listed below:

- Start the process of community engagement and local stakeholders, according to methodologies adhering to VCS standards.
- Preparation of an informative pamphlet for distribution to stakeholders with relevant information about the project.
- Identify local stakeholders inserted in the project area or that are directly or indirectly related to the study region (associations, cooperatives, cultural groups, etc).
- Meet/visit landowners, public-private agents and institutions of interest, members of the surrounding communities, to disseminate project information.

● Hold a Presentation Meeting, if mobilization is feasible, for stakeholders and members of the surrounding communities to be engaged in the project.

● Identify priority issues of great relevance to the communities, including scenario assessment regarding gender and intergenerational issues, land conflicts, working conditions, violence rates, and access to public services.

● Identify priority territories for actions and engagement of potentially relevant communities for the project, by applying and proving the use of participatory methodologies.

● Ensure the production of evidence that includes the prior consent of the communities and actors of interest to the project.

2.2.1 Methodology

The work methodology was defined after successive meetings and alignments between the consulting team that would go to the field and Systemica's technical team. During these meetings it was promoted a joint construction of strategies and the choice of the best tools to be used with the communities.The bullet points below shows the methodology defined to engage and mobilize the local population, aiming to be effective in the consultation process with surrounding communities and stakeholders. As defined by the VCS standards, the following was done:

- Application of simplified questionnaire with actors and members of interest for recognition/identification of the scenarios constituted in the territories under study;
- Signing of an authorization term for the use of information and images;
- Conducting a presentation/opening meeting of the project for the target public to be mobilized during fieldwork[33];
- Survey of primary information, through visits that will be documented, which will subsidize the production of a social diagnosis of the communities of interest to the project;
- Active search for the project's stakeholders, including the institutional ones and potential partnerships, aiming at the consultation and presentation of the project and its premises;
- Promotion of specific approaches with the delivery of an informative pamphlet containing the permanent communication channels for the project (e-mail: triunfodoxingu@systemica.digital and WhatsApp number: (11) 5039-1386).
- Development of a communication procedure to be approved with the community that aims to propose organized communication flows between Systemica, Caboclo Village and other local stakeholders of the project, where communication will be planned to present the risks, costs and benefits that the project may bring to local stakeholders, as well as all relevant laws and regulations covering workers' rights.[34].

[33] Annex: 230515_REDD+_Capacity_Building.zip

[34] Annex: 231605_Communication_Procedure.pfd

2.2.2 Results of the mobilization

All the information needed to engage the communities in the project was provided during the collective meetings held, including the REDD+ capacity building activity, on August 31, 2022.

This meetings had the objective to explain the main points and implications of implementing a carbon credit project, as well as disseminating and mobilizing the community to participate in the application of the questionnaire for socio-environmental diagnosis, assessing the priorities and most urgent demands.

It is noteworthy that during these activities the participation of the communities was prioritized, as well as the clarification of doubts about the project, in addition to being an opportunity to discuss, along with the populations of interest, some of the REDD+ capabilities, with the facilitator focusing mainly on the following topics: (i) reducing emissions from deforestation; (ii) reducing emissions from forest degradation; (iii) how to contribute to the increase of forest carbon stocks; (iv) actions and attitudes that can contribute to the control of climate change and global warming[36].

Individual approaches were also promoted, where everyone engaged by the research team received the project's pamphlet[37], containing information about the ongoing work, as well as the communication channels to address potential doubts or questions that arise from the beginning of the development and implementation of the planned activities. This approach methodology was defined to initiate and ensure effective participation, as well as the understanding of the most relevant prerogatives for the continuation of the project.

The application of the planned methodologies and tools during the fieldwork prioritized the participation and inclusion of the community's viewpoints. To guarantee the transparency of the consultation process, each interviewed stakeholder was asked to sign the "Authorization for Use of Information Term"[38], aiming at guaranteeing the informed consultation process, which certifies both their awareness of the project's objectives and the receipt of the informative pamphlet. It is noteworthy that special attention was given to making the language of the material more accessible, with the choice of an enlarged font, which aimed to facilitate the visualization of people with low vision or reading difficulties. The text of the pamphlet was designed to simplify the understanding and to facilitate reading, ensuring that the information was direct, and objective. There was also a concern on the part of the field team to pass on the information in a clear way, avoiding technical terms and words that could hinder the understanding of the content, in addition to the care taken to clarify each of the questions and doubts presented by the members of the mobilized communities .

The application of the questionnaires met the goal of approaching most of the members of the Caboclo Village community. From 21 heads of household who live permanently in the community, 17 were interviewed by the Systemica research team, which corresponds to a percentage of approximately 80%

[36] Annex: 230515_REDD+_Capacity_Building.zip

[37] Annex: 221018_Pamphlet.pdf

[38] Annex: 221014_ Authorization for Use of Information - Caboclo Village.pdf

of the total universe. This produced material will be used for the development of the social diagnosis, which will define the demands and opportunities observed in this population, and which will be able to enhance the development of the planned actions, as well as the achievement of the expected results.

Results of all activities developed, including information on location, date and number of participants involved are summarized in Table 2.2.

Table 2.2. Results of the activities with the community of Caboclo Village

Activity	Location	Date	Participants
Questionnaire for social diagnosis	Caboclo Village	29-08 a 01-09	17
Start Date and Capacity Building Meeting for REDD+ Activities	Caboclo Village	31/08/2022	13
Explanation of the Project, delivery of pamphlet and inauguration of communication channel	Caboclo Village	29-08 a 01-09	50

It is important to stress that all comments regarding the project implementation received through our communication channels previously mentioned in this section will be addressed individually and therefore documented. In addition, any arising complaints or suggestions for improvement will also be taken into consideration and judged internally by the project proponent, according to the communication procedure[41]. If the complaint or suggestion is pertinent and related to the scope of the project's obligations, it will be implemented.

Regarding the employees working at the Santa Maria farm, the farm hires permanent and temporary employees. Since only the managers of the farm have relation to the project activities, only them was identified as stakeholder in the Santa Maria farm.

All workers that have any correlation with the project area and activities are duly registered and have their contracts in full compliance with the Consolidation of Labor Laws (CLT), which is the document that regulates formal labor in the country and defines rules about how labor relations shall be conducted. Moreover, the landowners are committed to Systemica, the project's partner and developer, to honor their labor obligations [42, 43]. Finally, the owners do not have any labor liabilities, in other words, no debts due to non-compliance with labor obligations, incorrect payment of social charges, nor payment of mandatory benefits.

The communication about project design and implementation, including information about project monitoring, risks, costs and benefits to local stakeholders, relevant laws and regulations, and auditing processes is planned and will be carried out according to the communication procedure that will be

[41] Annex: 231605_Communication_Procedure.pfd

[42] Annex: 221226_Systemica-Sefer contract.pdf

[43] Annex: 221014_Systemica-Didácio contract.pdf

approved with the community[44].. In addition, the local community was informed about the upcoming visit of the validation body of the VCS Program [45,46].

2.3 Environmental Impact

No negative environmental impacts are observed since the project area is not affected by any kind of business activity and no exploitation activity. This information was reported by the landowners and by the community interviewees during the stakeholders' consultation[47].

All properties composing the project are situated within The Triunfo do Xingu Environmental Protection Area. Sefer properties are located in the extreme north of it, bordering the Terra do Meio Ecological Station, the Nossa Senhora Aparecida farm (owned by Didácio Barros) are 20 km south. Going east from any part of the project area, the APA Triunfo do Xingu frontier makes contact with the the Serra do Pardo National Park. Other important conservation units in the region are the Iriri State Forest, Altamira National Forest, Jamanxim National Park, and the extractive reserves Ríozinho do Anfrísio, Rio Iriri, and Rio Xingu, located at up to 100 km from the area. [48] Given its proximity to conservation units and the large extensions of native forest on the properties, the project areas improve and contribute to various ecological services, such as the conservation of ecological corridors, the existence and maintenance of rich fauna and flora biodiversity, land fragmentation control, biodiversity refuge, connection and continuity between the project area and the conservation units (national parks, extractive reserves, ecological stations, national and state forests).

The region is home to various endangered and vulnerable fauna and flora: at least 13 endangered species and more than 50 vulnerable species were recorded according to the classification of the International Union for Conservation of Nature (IUCN), Ministry of Environment (MMA), and Secretary of State for Environment and Sustainability (SEMAS/Pará).[49, 50, 51, 52, 53, 54]

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[44] Annex: 231605_Communication_Procedure.pfd

[45] Annex: 230515_REDD+_Capacity_Building.zip

[46] Annex: 221014_ Stakeholder Consultation-Caboclo Village-Questionnaires.pdf

[47] Annex: 221014_ Stakeholder Consultation-Caboclo Village-Questionnaires.pdf

[48] Annex: 221014_ Socioeconomics_ConservationUnits_rev2.pdf

[49] Annex: 221014_ Terra do Meio Ecological Station MP.pdf

[50] Annex: 221014_ Serra do Pardo National Park MP.pdf

[51] Annex: 221014_ Iriri River Extractive Reserve MP.pdf

[52] Annex: 221014_ Xingu River Extractive Reserve MP.pdf

[53] Annex: 221014_ Riozinho do Anfrisio Extractive Reserve MP.pdf

[54] Annex: 221014_Altamira National Forest MP.pdf

To conclude, the project by itself will not bring any other potential environmental impact to the region, it will do the opposite. By generating VCUs, the landowners and the project management team will be able to do the monitoring activities proposed in section 5 of this PD and avoid the unplanned deforestation, which is the main potential environmental impact.

2.4 Public Comments

The project's 30-day public comment period ran from October 31, 2022 to November 30, 2022. During this period, no comments were received.[55]

2.5 AFOLU-Specific Safeguards

2.5.1 Identification of stakeholders potentially impacted by the project.

The properties that are part of the Triunfo do Xingu Grouped REDD+ Project are in the central region of the municipality of Altamira, in the state of Pará. This is the largest municipality in Brazil, with 159,533,306 Km^2 and an estimated population of 115,969 inhabitants (IBGE, 2022c). Through satellite images[56], secondary data from desk research and primary data surveys carried out through fieldwork, a radius of 20 km from the property's limits were defined and the communities in Section 2.1 were identified.

The communities identified in the region are mostly rural villages, and in general present great social and environmental vulnerability, requiring the formulation of clear policies, with well-defined rules regarding land tenure and occupation. In Canopus Village, for example, there is the irregular use of land for illegal mining, with the presence of deforestation and ownership claims of various sizes, including those of large land grabbers. (Escada et al., 2005).

The community of Caboclo Village is a rural village, where most of the residents live off subsistence farming and rural services, with most of the local labor being allocated to harvest periods, or to jobs linked to the farms in the region. Of the 21 households of fixed residents identified at Caboclo Village community, 17 were interviewed[57] by Systemica's research team. The field team interviewed and distributed an informative pamphlets[58], highlighting the communication channels open to the community to access questions and complaints about the project, in each household visited[59].

Caboclo Village was named after the Caboclo river, affluent of the Xingu River, although its real name - Irinópolis Village - is practically unknown by the community itself. It is estimated that it has about 100 inhabitants, if you consider the population concentrated along the main road that gives access to

[55] Annex: 221205_Public Comment Verra's Email.pdf

[56] Annex: 221014_ Socioeconomics_Location_rev.pdf

[57] Annex: 221014_ Stakeholder Consultation-Caboclo Village-Questionnaires.pdf

[58] Annex: 221018_ Pamphlet.pdf

[59] Annex: 221014_Map_Visited households.pdf

Canopus Village, plus the surrounding properties. Regarding the number of inhabitants, the number informed by the local Health Center team was 30 Men, 23 Women and 16 children, a total of 69 residents. However, it is believed that the size of this population may be underestimated since the Novo Pacto Municipal School informed a number of 48 students enrolled throughout the 9 grades of elementary school offered. This information was provided by the principal of the institution. This number of students leads us to believe that the population of the region must be larger, especially in the surrounding areas, where statistics and official data are outdated. No specific information about the local communities, their population, number of families, and economic and social data was found at the City Hall. To better understand the reality of the Caboclo Village community, a map with the important infrastructure buildings surrounding of Nossa Senhora Aparecida Farm is attached[60].

One important fact to the mentioned population underestimation is the outdated Brazilian Census, the last one of it was done in 2010. The Census in Brazil is carried out every decade, but the Brazilian government has delayed it and until the present moment, October of 2022, it has not been concluded. The situation creates a great difficulty in obtaining real and updated data about the Brazilian regions, rural areas, especially in the Legal Amazon, where there is a gap in the actions of the government, absence of environmental enforcement policies, and lack of basic services to the population.

Not only local communities were identified[61], but also but also institutional stakeholders and the administrators of the project farms[62] possibly involved in the project were mapped to better understand the project impacts public. The process of consultation and explanation about the project's prerogatives was done by telephone calls and by e-mail with institutional stakeholders[63] containing a digital version of the pamphlet, contact number and information about the project.

The institutional stakeholders and other stakeholders were classified and prioritized, according to their respective work fields and relevance to the project: (i) Municipal institutions – Altamira; (ii) Municipal institutions - São Félix do Xingu;(iii) State institutions - Pará; Land Institute of Pará (ITERPA); (iv) Deliberative Council of the APA Triunfo do Xingu (ATX); (v) Project farms (Administrators). They can potentially become partners in the project, to ensure the efficiency and increase the scope of the planned actions. A spreadsheet containing the main agents identified that could be impacted by the project's activities (local agents identified and mobilized and institutional actors of interest to the project) and their contact telephone numbers and e-mails, can be found in the attached spreadsheet[64].

2.5.2 Identification of any legal or customary tenure/access rights to territories and resources, including collective and/or conflicting rights, by local stakeholders.

[60] Annex: 221014_Socioeconomics_Caboclo_Village_infraestructure.pdf

[61] 230314_Caboclo_Village_list.pdf

[62] 230314_Stakeholder_list.pdf

[63] Annex: 230309_Stakeholder_consultation.zip

[64] Annex: 230314_Stakeholder_list.xlsx

The surrounding of the project has a history of land invasions and irregular occupations, and Caboclo Village itself is a result of the process of human occupation in areas that have been relegated by both public authorities and private initiative. The occupation of this stretch started in 1980 and was intensified in the 1990s, through the invasion of portions of land and structures that were left after the bankruptcy of the mining industry that operated in the region. The following excerpt reports the historical process of occupation of the so-called "New Frontiers of the Amazon" located in the region between the Iriri and Xingu rivers:

> “The opening of the Canopus Mining Company Road, which exploited cassiterite in the mid-1980s, allowed the entrance of logging companies, the arrival of workers, and the formation of various population centers. Around 1998-2000, a new cycle of business activities began, this time of ranchers, speculators, and cattle ranchers who appropriated the land, using the vast network of roads left behind by the logging companies, accelerating the occupation of the region” (Escada et al., 2005).

However, the conflicts and pressures coming from invasions and squatting have not reached the properties boarders. Even being inside a complex region, both landowners, Didácio de Barros and Rafael Sefer, do not face land tenure or resource access and use disputes. All legal documentation and proof of title are available in annex in the sections 1.7 and 1.14 of this PD.

During the socio-environmental assessment carried out, no interviewed inhabitant of Caboclo Village reported living from seed collection or extraction of non-timber products of any kind in the project area. 100% of the participants affirmed that they do not use the territory of Nossa Senhora Aparecida farm, which is 8 km away from the village, either for gathering, fishing, or hunting.. Rafael Sefer also informed, in a survey[65] applied by Systemica, that in the project area of his properties no people or surrounding communities use the forests for extractivism, hunting, fishing or any other type of activity, and he does not authorize any use of the forest in the project area.

The forest in which the project is inserted is in an environmental protection area and is formed by native species. Due to its protected status and since the owners do not intend to harvest the forest or market non-timber products, the project does not introduce invasive species, and therefore does not use species that may cause adverse effects, nor does it use fertilizers, pesticides, or biological control agents.

2.5.3 Legal and moral responsibility of the project with stakeholders (institutional and community) and workers of the properties involved in the project.

All technical aspects of the project were presented to the Caboclo Village community during interviews, training and through pamphlets and emails.In these meetings the entire VCS validation and verification process was addressed[66, 67].. The project has developed a communication procedure and intends to evaluate and validate it with the community of Caboclo Village. The monitoring results, and the intentions,

[65] Annex: 230307_RafaelSeferSurvey_2022-08-08.pdf

[66] Annex: 230515_REDD+_Capacity_Building.zip

[67] Annex: 221014_Stakeholder Consultation-Caboclo Village-Questionnaires.pdf

risks, costs, and benefits of the project are foreseen and will be communicated according to the communication procedure[68]. . The communication procedure foresees some communication channels that are already active and serve to allow the exchange and answer any questions that may arise from the interested parties (WhatsApp groups whith Caboclo Village members)[71].

The communication procedure provides that all comments regarding project implementation or complaints and conflicts received through our communication channels will be treated individually and therefore documented[72]. In addition, any complaints, suggestions or conflicts that arise will also be taken into consideration and judged by an internal committee according to Systemica's Code of Ethics and Conduct[73] and, if pertinent and related to the scope of the project obligations, will be implemented, as is described in the conflict resolution procedure that is described within the communication procedure.All workers that have any correlation with the project area and activities are duly registered and have their contracts in full compliance with the Consolidation of Labor Laws (CLT), which is the document that regulates formal labor in the country and defines rules about how labor relations shall be conducted. All relevant laws are stated in this document. Moreover, the landowners are committed to Systemica, the project's partner and developer, to honor their labor obligations, which includes the commitment to not tolerate any kind of discrimination or sexual harassment[76, 77]. Finally, the owners do not have any labor liabilities, in other words, no debts due to non-compliance with labor obligations, incorrect payment of social charges, nor payment of mandatory benefits.

The legal contract signed with the owners proves that they have 100% legal control of the areas and that there are currently no land conflicts. If conflicts of this nature occur in the area, the legal authorities will be immediately notified and Systemica's juridical department will act to solve these conflicts.

2.5.4 Description of the social, economic, and cultural diversity within the local stakeholder groups.

The stakeholders of the project are government agencies, municipalities, universities, environmental and agricultural agencies, project farm administrators and the Caboclo Village. Thus, by identifying and applying different forms of consultation, to the various stakeholders, the project is considered to encompass the social, economic, and cultural diversity of the different stakeholders.

[68] Annex: 231605_Communication_Procedure.pfd

[71] Annex: 230516_Communication_Established.pdf

[72] Annex: 230519_Conflicts_and_Grievances_Form.xlsx

[73] Annex:

230519_Systemica's Code of Ethics and Conduct.pdf

[76] Annex: 221226_Systemica-Sefer contract.pdf

[77] Annex: 221014_Systemica-Didácio contract.pdf

2.5.5 Significant changes in the composition of local stakeholders over time.

No changes were identified among the stakeholders involved with the project. Any future significant changes will be reported in this section.

Communication with the project team was promoted with all stakeholder profiles, through field work, calls, and meetings. For government agencies, private companies, and NGOs it is stablished an online communication channel by e-mail and form. However, direct consultation was also carried out with municipal departments and unions, as evidenced throughout the text.

Among other additional positive impacts expected by the community are projects performed with the municipal school Novo Pacto, with the local health center, job, and income generation opportunities, specially targeting the improvement of opportunities for women and young people. These projects have a close impact on the sustainable development goals for 2030, defined by the United Nations, in the fight against hunger and poverty eradication, improving the quality of education, access to health care, employability of the population, and economic growth, reinforcing gender and equality issues, in addition to combating climate change and protecting biodiversity.

2.5.6 Expected changes in well-being compared to the baseline scenario, including changes in ecosystem services identified as important to local stakeholders

Considering that the surrounding community does not exploit resources (non-timber forest products or others) within the project area, it is commonly understood that the operation of the business or the project activities themselves will not have any negative impact on the ecosystem services associated with extractivism activities.

From the information collected, it is understood that there are no direct or indirect risks to local stakeholders associated with project activities, since the owners do not allow any kind of extractivism or permanence within the project areas, therefore, there are no communities occupying the internal part of the project area and the only identified community dependence is the use of the caboclo stream for fishing and swimming, considering that part of its water regulation and water quality is provided through a preserved catchment located in part of the project area, as demonstrated in section 2.2. As the project activities have a preservation objective, the provision of these ecosystem services will not be harmed in any way, in fact, it will only be more assured.

. Well known benefits of maintenance of forests are related to supporting and regulating ecosystem services, such as air quality regulation, climate regulation, water regulation, protection against erosion, degradation process, soil formation and regeneration, pollination, biological regulation, nutrients, and life -maintenance cycle, protection of the gene pool (Loft, 2011). Among other additional positive impacts expected by the community are projects performed with the municipal school Novo Pacto, with the local health center, job, and income generation opportunities, specially targeting the improvement of opportunities for women and young people. These projects have a close impact on the sustainable development goals for 2030, defined by the United Nations, in the fight against hunger and poverty eradication, improving the quality of education, access to health care, employability of the population, and economic growth, reinforcing gender and equality issues, in addition to combating climate change and protecting biodiversity.

No risks affecting the environment, biodiversity and the community are identified. If any risk is reported by the community via our previously mentioned ongoing communication channels or observed by our local consultants, as presented in the communication procedure, during the life of the project, including the design and consultation phase, an investigative inquiry will be opened in Systemica's internal committee so that measures can be taken as mentioned in section 2.5.3.

2.5.7 Location of communities, local stakeholders, and areas outside the project area that are expected to be impacted by the project

Aware that there could also be other local actors, for whom the development and execution of the project may cause direct or indirect impact, other communities such as to Indigenous and Quilombola, recognized traditional communities and settlements projects were identified through satellite images [78, 79, 80]. The list of these communities and its distance to the project areas are identified below in Table 2.3

Table 2.3.Distance (straight line in km.) from the indigenous communities, quilombolas and settlements near the farms that make up the Triunfo Do Xingu Grouped Redd+ project

Communities Indigenous Lands	Santa Maria Farm	Nossa Senhora Aparecida Farm
KuruSya	89	112.16
Xipaya	101.5	140.9
Cachoeira Seca	134.8	186.8
Kararal	157.64	196.2
Arawet	89.9	102.8
Apyterewa	105	96.86
Ba-	136.9	113.27
Menkragnnoti	162.7	118.5
KayapT	172	114.76
Xirin do Rio Catete	291.7	262.86
Quilombolas (Afro-Brazilian settlements)	**Santa Maria Farm**	**Nossa Senhora Aparecida Farm**
Rio Andirs (Parte 01)	475	529.5
Maria Valentina	361.5	429

[78] Annex: 221014_Socioeconomics_SettlementProjects_rev.pdf

[79] Annex: 221014_Socioeconomics_QuilombolaCommunities_rev.pdf

[80] Annex: 221014_Socioeconomics_IndigenousLands_rev.pdf

Cocalinho	539	532.5
Ilha de Senhor Vicente	610	583
Santa Fé e Santo Antônio	540	551
Bailique Beira, Bailinque Centro, Pocão	528.5	536
Igarape Preto, Baizinha, Panpelonia, Teófilo	542	555.5
Porto Grande,Mangabeira, São Benedito de viseu	563	577.5
Porto Alegre	565.9	580
Tomazia, Tachizal, Itapocu, Mola, Bonfim,Frade	560	587
Settlements	**Santa Maria Farm**	**Nossa Senhora Aparecida Farm**
PDS Terra Nossa	220.6	212.56
PDS Nelson Oliveira	229.5	243.7
PDS Vale do Jamanxim	235.6	240.6
Resex Riozinho do Anfrisio	173.73	187.5
Resex Rio Iriri	83.8	129.2
Resex Rio Xingu	89.6	80.57
PA São Sebastião do Xingu	137.6	108
PA Sumuama II	143.7	105.9
PA Colonia São Jose do Xingu	161.8	134.9
PA Pombal	107.72	77.7
PA Tancredo Neves	178.06	148.5
PA Belauto	206	168.3
PA Oeste	246.5	204.53
PA Tucuma	251.5	211.9
PA Barra Mansa	246	220.7
PA Sudoeste	255.5	235.7

2.5.8 Location of territories and resources that local stakeholders possess or to which they have regular access

There are no local stakeholders who profit from the resources produced by the project farms, nor is there any type of economic activity associated with the extraction of forest or biodiversity products within the project area.

<u>Process of consultation and continuous communication channel</u>

Communication and stakeholder engagement took place through direct community contact around the project area during the months of August and September 2022. The families of Caboclo Village and the managers of Santa Maria Farm were visited by Systemica's research team[81], who explained the project and provided the contact phone number, a WhatsApp number, and email address to ensure multiple and continuous communication between project's responsibles and stakeholders. In this visit, a questionnaire was applied to carry out a socio-environmental diagnosis with the Caboclo Village community, in order to assess the impacts of the project on their lives and their opinion about the activities developed by the farm, working conditions, forms of organization, etc. In addition, it is worth mentioning that with regard to the institutional actors an e-mail was sent informing the contact information for discussing any arising questions about the project as well as the primary information about the project itself, including an informative pamphlet, as mentioned before.

2.5.9 Experience of the team involved in the project

The team responsible for planning the activities, carrying out the diagnosis, and analyzing the data is made up of a multi-skilled, multidisciplinary team. Attached is a complete description and experience of the Systemica team[82] and the contracted field employees who executed the meeting with local communities and the field surveys[83, 84].

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

This grouped project uses the approved VCS methodology VM0015 Methodology for Avoiding Unplanned Deforestation (AUDD) v1.1, published on 03-December-2012 (VERRA, 2012a).

Also, the following tools were used:

- VT0001 – Tool for demonstration and assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities, v3.0, published on 01-February-2012 (VERRA, 2012b).
- AFOLU Non-Permanence Risk Tool v4.0, published on 19-September-2019 (VERRA, 2019).

3.2 Applicability of Methodology

The applicability of each methodology used is available in Table 3.1 and Table 3.2.

[81] Annex: 221014_Stakeholder Consultation-Caboclo Village-Questionnaires.pdf

[82] Annex: 221014_ Systemica_experience.pdf

[83] Annex: 221014_ CV - Caroline Césari de Oliveira - Oct2022.pdf

[84] Annex: 221014_ CV - Marco Aurélio - Aug2022.pdf

Table 3.1. Applicability conditions for VM0015 (VERRA, 2012a) Methodology for Avoided Unplanned Deforestation, v1.1.

Applicability Conditions (Section 2)	Project attendance
a) Baseline activities may include planned or unplanned logging for timber, fuel-wood collection, charcoal production, agricultural and grazing activities as long as the category is unplanned deforestation according to the most recent VCS AFOLU requirements	None of the baseline land-use conversion activities are legally designated or sanctioned for forestry or deforestation, and hence the project activity qualifies as avoided unplanned deforestation. This is in accordance with the definition of unplanned deforestation under the VCS Standard v4.4.
b) Project activities may include one or a combination of the eligible categories defined in the description of the scope of the methodology.	Project activities are eligible within the "Avoided Deforestation without Logging in the Project Case", category A. Degradation is not considered in any part of the baseline or project scenario.
c) The project area can include different types of forest, such as, but not limited to, old growth forest, degraded forest, secondary forests, planted forests and agro-forestry systems meeting the definition of "forest".	The forest classes that compose the project area are named as per Technical Manual for Brazilian Vegetation (IBGE, 2012). No deforested, degraded or areas otherwise modified by humans were included in the project area.
d) At project commencement, the project area shall include only land qualifying as "forest" for a minimum of 10 years prior to the project start date.	The area is considered forest as per the definition (Ramírez & Morales, 2021): "Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ". Also, satellite images that will be used for the baseline scenario analysis shows that the project area has only native forests qualified as forests for more than 10 years prior to the project start date.
e) The project area can include forested wetlands (such as bottomland forests, floodplain forests, mangrove forests) as long as they do not grow on peat. Peat shall be defined as organic soils with at least 65% organic matter and a minimum thickness of 50 cm. If the project area includes a forested wetlands growing on peat (e.g. peat swamp forests), this methodology is not applicable	Not applicable. The project area does not have any forested wetlands[85].

Table 3.2. VT0001 (VERRA, 2012b) Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities, v3.0.

[85] Annex: 221014_mapbiomas-classification.jpeg

Applicability Conditions (Section 1.2)	Project attendance
AFOLU activities the same or similar to the proposed project activity on the land within the proposed project boundary performed with or without being registered as the VCS AFOLU project shall not lead to violation of any applicable law even if the law is not enforced.	The activities within the proposed project boundary does not lead to violation of any applicable law even if the law is not enforced. Also, they follow all the VCS methodologies requirements.
The use of this tool to determine additionality requires the baseline methodology to provide for a stepwise approach justifying the determination of the most plausible baseline scenario. Project proponent(s) proposing new baseline methodologies shall ensure consistency between the determination of a baseline scenario and the determination of additionality of a project activity.	The most plausible baseline scenario is being development under the stepwise approach of VM0015 methodology, which is available as an eligible methodology in the Verra website.

3.3 Project Boundary

3.3.1 Spatial boundaries

Reference Region

The Reference Region (RR) is the spatial demarcation for gathering information on rates, agents, and patterns related to deforestation, which is used for historical analysis of land use change and projection of future deforestation, and its monitoring.

The RR was defined based on the dynamics of deforestation as well as physical and ecosystem aspects of the landscape and its similarity to the PA. To define its spatial boundaries, Integral protection conservation units were excluded (Parque Nacional da Serra do Pardo and Estação Ecológica da Terra do Meio) and the south used the road to delimit the Reference Region.

Generally, the guidelines and criteria for the management, use, and control of natural resources in an APA are regulated by a management plan. However, in the APA Triunfo do Xingu - Conservation Unit for Sustainable Use - instituted by state decree 2612 in 2006, where the RR was allocated, there is no consolidation of a management and zoning plan after 15 years since its establishment.

There is no sub-national or national baselines. As a consequence of nonexistent regulation and lack of governance, this is the region of Brazil with the highest rate of unplanned deforestation, about 40% of the APA's Forest area has already been converted to other uses, mainly for livestock (Hashizume, 2021).

The RR delimited equivalents 425,016.608 hectares, which includes the Project Area of 10,636.02 hectares (Figure 3.1). VM0015 (VERRA, 2012a) recommends that when the PA is under 100,000 hectares, the Reference Region must be 20 to 40 times larger than the PA. In this case, the Reference Region is 39,96 times larger than the Project Area. RR although have included different municipality areas - Altamira and São Felix do Xingu -, they have similar dynamics. So, PA deforestation is likely to occur in a manner like that observed in the RR.

The RR is 89% in Altamira, equivalent to 379,727.69 hectares, and 11% in São Felix do Xingu, equivalent to 45288,91 hectares. In this first instance, the properties involved in the Project are located only in Altamira.

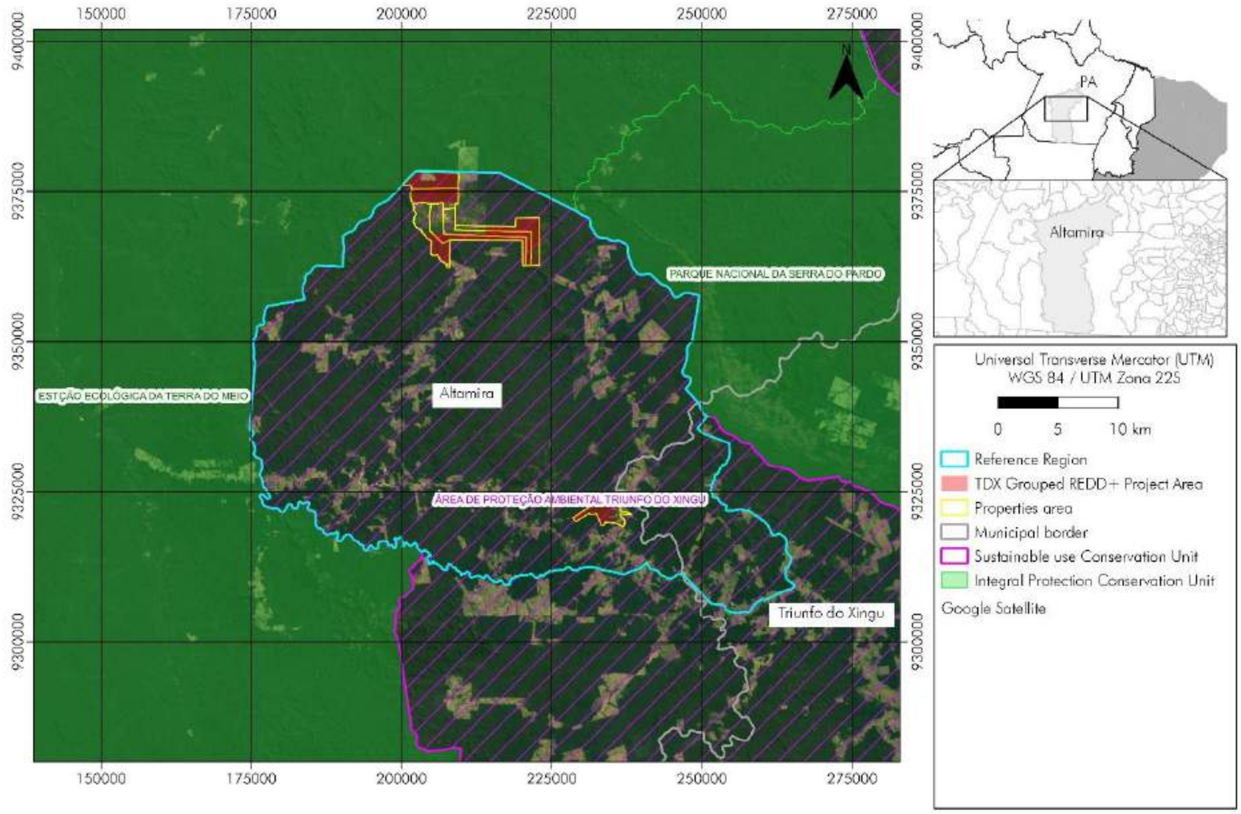


Figure 3.1: Location of the Reference Region and Project Area.

3.3.2 Project Area

The Triunfo do Xingu Grouped REDD+ Project, in its first instance, is composed of seven properties as described in Section 1.12. The coordinates represented by these properties composing the Triunfo do Xingu Grouped REDD+ Project are presented in archive .kml[86] (Figure 3.2).

[86] Annex: 221014_ project_area_TdX.kml

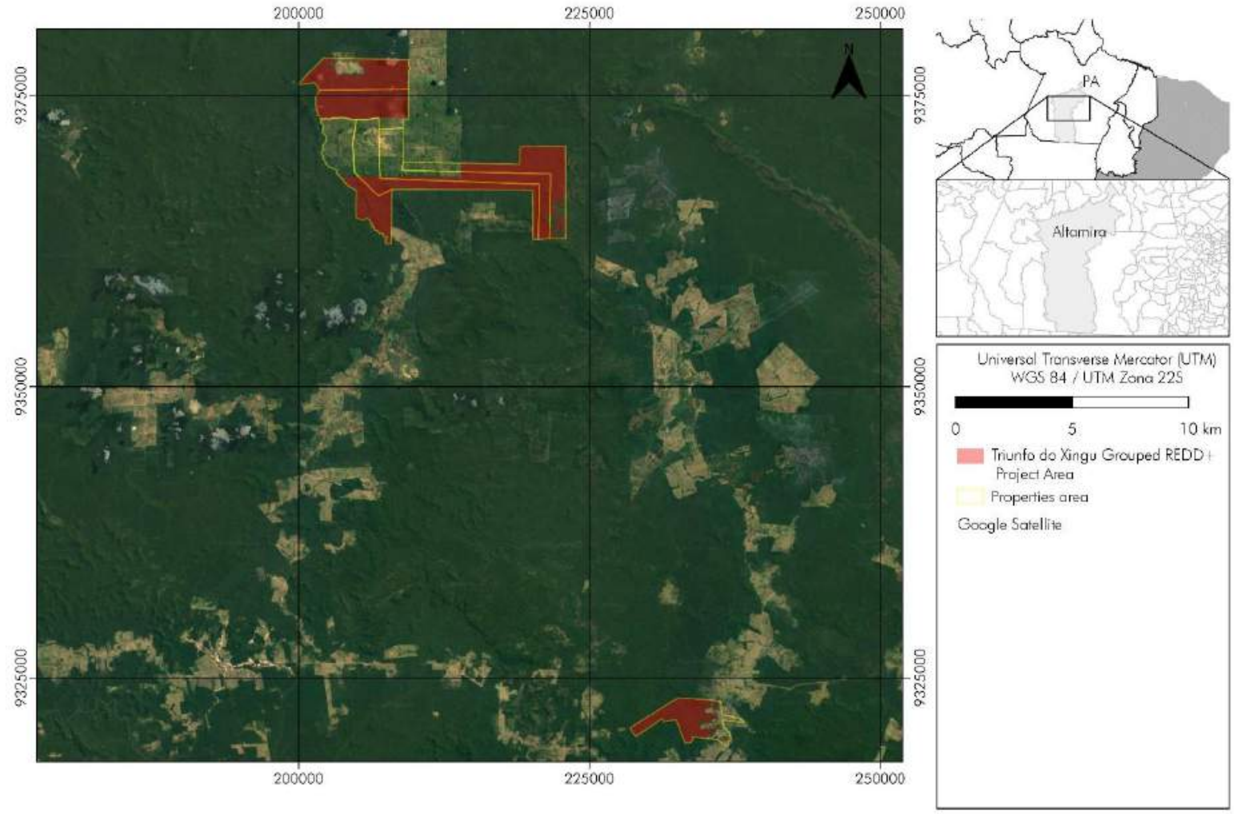


Figure 3.2. Triunfo do Xingu Grouped REDD+ Project Area *and boundaries of the* seven properties

The Project Area (PA), defined following the methodology's VM00015 (VERRA, 2012a), corresponds to the area covered only by forest for at least 10 years before the project start date, resulting in 10,636.02 hectares (Table 3.3).

Table 3.3: Triunfo do Xingu Grouped REDD+ Project Area, in hectares, per properties

Farm's name	Hectares
Nossa Senhora Aparecida	1,406.79
Campo Lindo	1,792.98
Santa Marta	1,355.40
Retiro Encantado	1,242.27
Vó Lina	1,101.51
Patacho	1,901.16
Belcon	1,835.91
Total	**10,636.02**

The Project Area (PA) is defined by the eligible forest, defined as mature native vegetation over 10 years old. The entire area of forest that is within the properties that make up the TdX Project was defined as PA, except for a small part of forest equivalent to 26.10 hectares of the Belcon property was excluded - representing 0.19% of the five properties in total. It is considered non-eligible because it is located to the north, exceeding the limit within the Terra do Meio Ecological Station Integral Protection Area (due to overlapping vectors).

3.3.3 Similarity analysis between Reference Region and Project Area

The three main criteria relevant to demonstrate that the conditions which determine the probability of deforestation within the project area are similar to the reference region been met, according to the VM0015 methodology (VERRA, 2012a):

Agents and drivers of deforestation

The main dynamics in land use are the conversion of areas of native vegetation to implement livestock activities, and the magnitude of the decrease of native vegetation with simultaneous increase of pastures shows enormous pressure in the region around the Project Area.

There is historical evidence (described in this VCS-PD in Sections 1.13 and 4.1) to argue that the same deforestation pressures that apply to the Reference Region would also act in the Project Area at the same intensity and carried out by the same agents and motivated by the same drivers and groups of agents, as in the Reference Area.

Agent groups

APA Triunfo do Xingu has a very strong problem of land grabbing in its territory, with constant pressure from large companies and large ranchers for land. The destruction of forests within the APA is historically related to the activities of mining companies and illegal logging activities, followed by occupation by ranchers and land grabbers (COSTA, 2013). The latter are presently the main agents of deforestation in the RR region.

Infrastructure drivers

The construction and installation of new or improved infrastructure in the project area such as roads, railways, bridges, and hydroelectric reservoirs, is not foreseen.

Other spatial drivers expected to influence the Project Area

The southwest region of the RR, around Canopus Village, suffers from the advance of the agricultural frontier and land conflicts, which involve local communities and farmers to powerful national economic groups. The area is the target of land grabbers, gunmen, prospectors, and illegal loggers, due to their large stocks of hardwoods, ores, and public and vacant lands (ISA, 2012). However, it is worth noting that this reality is limited only to the extraction region, which takes place in the same area where the mine was explored three decades earlier and involves both regular activity and illegal mining (Cetem, 2014). Importantly, the mining activity is no longer a primary deforestation driver. In the areas surrounding Vila Canopus the deforestation is presently being caused by the same agents that operate in the remaining of the RR and pose a threat to the TdX project areas. Indeed, the expansion of pasturelands around the village can be seen in geospatial data rencently made available (MapBiomas, Col 7), as depicted in Figure 3.3. Notice that the actual mining area ceased to expand at least 15 years ago.

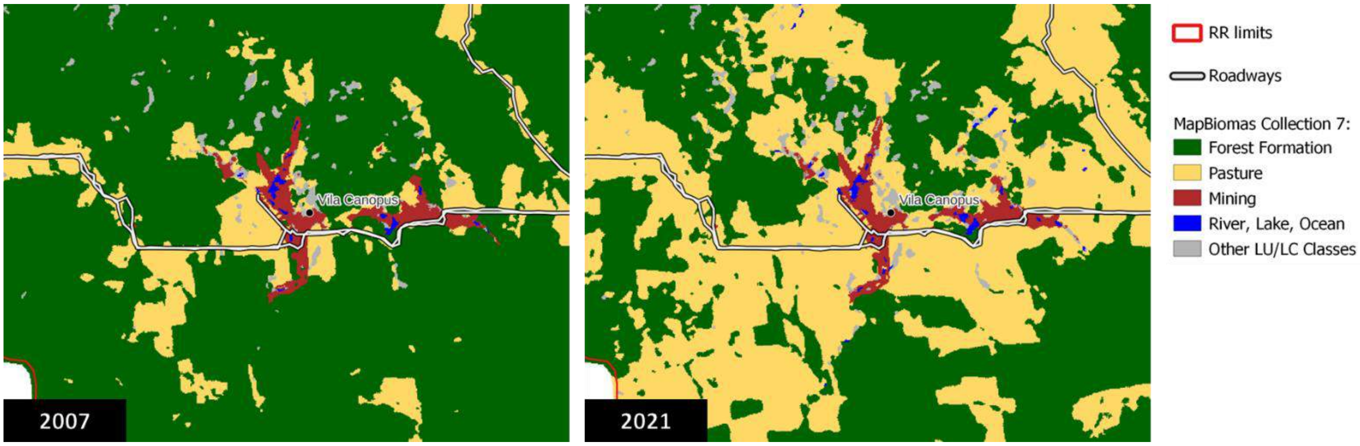


Figure 3.3. Expansion of pastures around the mining site located at Vila Canopus.

Landscape configuration and ecological conditions

Forest classes

The forest classes in the RR are Ombrophilous Forest of Open canopy, according to IBGE (IBGE, 2022a), covering 57% of the RR, Forest transition covering 31% of the RR, and 12% Ombrophilous Forest of Dense canopy. Regarding PA, 48.8% are Forest Transition, 8.4% are Ombrophilous Forest of Dense canopy and 42.8% are forests classified as Ombrophylous Open canopy. Figure 3.4 shows the spatial representation of these vegetation types in the PA and RR.

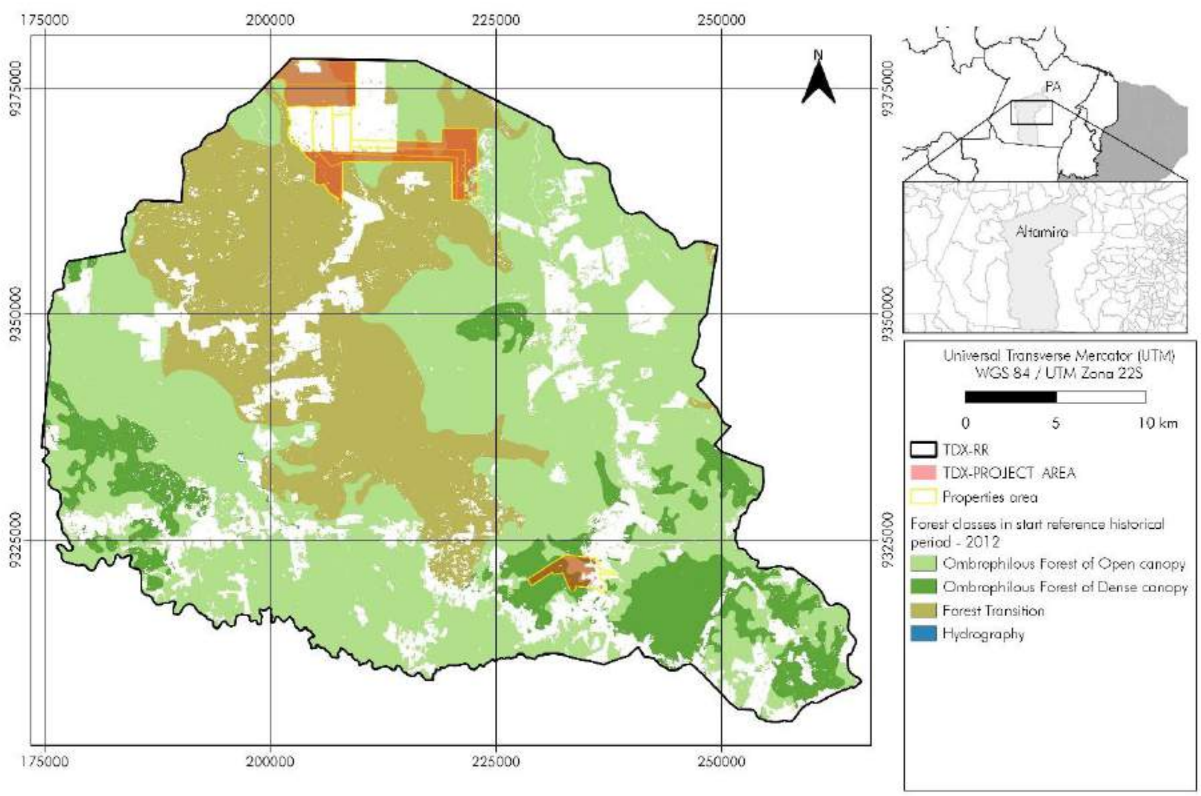


Figure 3.4: Identification of forest classes in the Reference Region and Project Area at the start reference historical period.

Therefore, 100% of the PA has forest classes that are in 100% of the RR meeting the methodology required for this specific similarity criterion (Table 3.4).

Table 3.4: Similarity analysis values between the Project Area and the Reference Region regarding landscape configuration and ecological conditions

		PA	RR
Landscape factors	**Forest classes**	**%**	**%**
	Forest transition	48.8%	31.0%
	Ombrophilous Forest of Dense canopy	8.4%	12.0%
	Ombrophilous Forest of Open canopy	42.8%	57.0%
		100.0%	**100.0%**

Rainfall analysis

In terms of climatic similarity of rainfall, the Project Areas and the Reference Region do not present distinctions regarding climatic variables, being, therefore, 100% similar, insofar as both fit entirely as a tropical rainy climate, according Koöpen climatic classification (Kottek et al., 2006).

Despite the municipality being located in a climatic transition, presenting the category Aw to the south, and Am to the north, the average precipitation for the climate Aw is around 2200 mm, and for the climate Am, around 2100 mm (Figure 3.5) (Hoffmann et al., 2018). The images used were from the MODIS/TERRA satellite, (product MOD11A2 V6/MOD11A2.006 Terra Land Surface Temperature and Emissivity 8-Day Global 1km). Each pixel value in MOD11A2 provides an average 8-day land surface temperature (LST) (WAN, 1999) .

Thus, the average annual precipitation in at least 90% of the Project Area is within ±10% of the average annual precipitation of at least 90% of the rest of the reference region, meeting the methodology required for this specific similarity criterion.

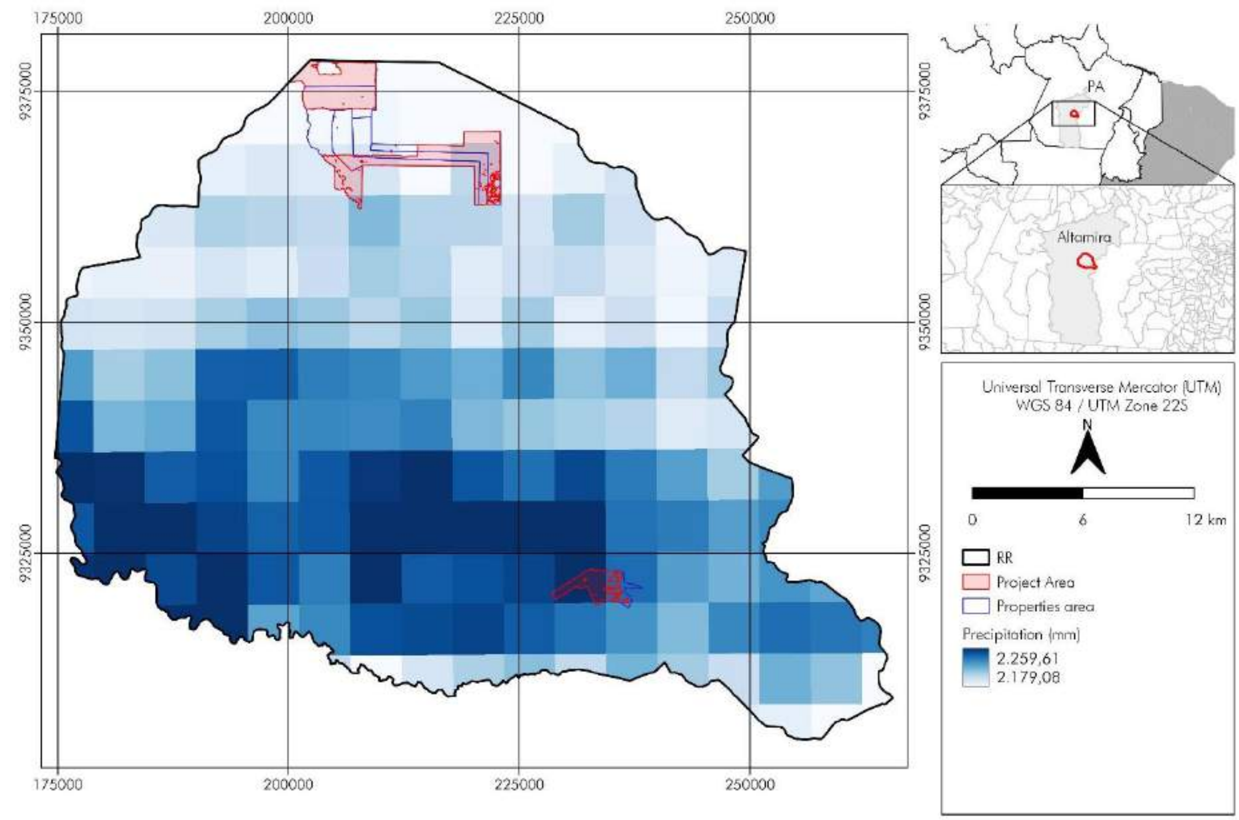


Figure 3.5: Average annual precipitation in the Reference Region and Project Area.

Elevation analysis

To classify the altitude of the PA and the RR, according to the criteria of the methodology, which requires 90% similarity between the two areas, a mosaic of digital elevation models, provided by NASA, with a spatial resolution of 30 meters (Farr et al., 2007). Figure 3.6 shows the elevation levels of the Reference Region and Project Area.

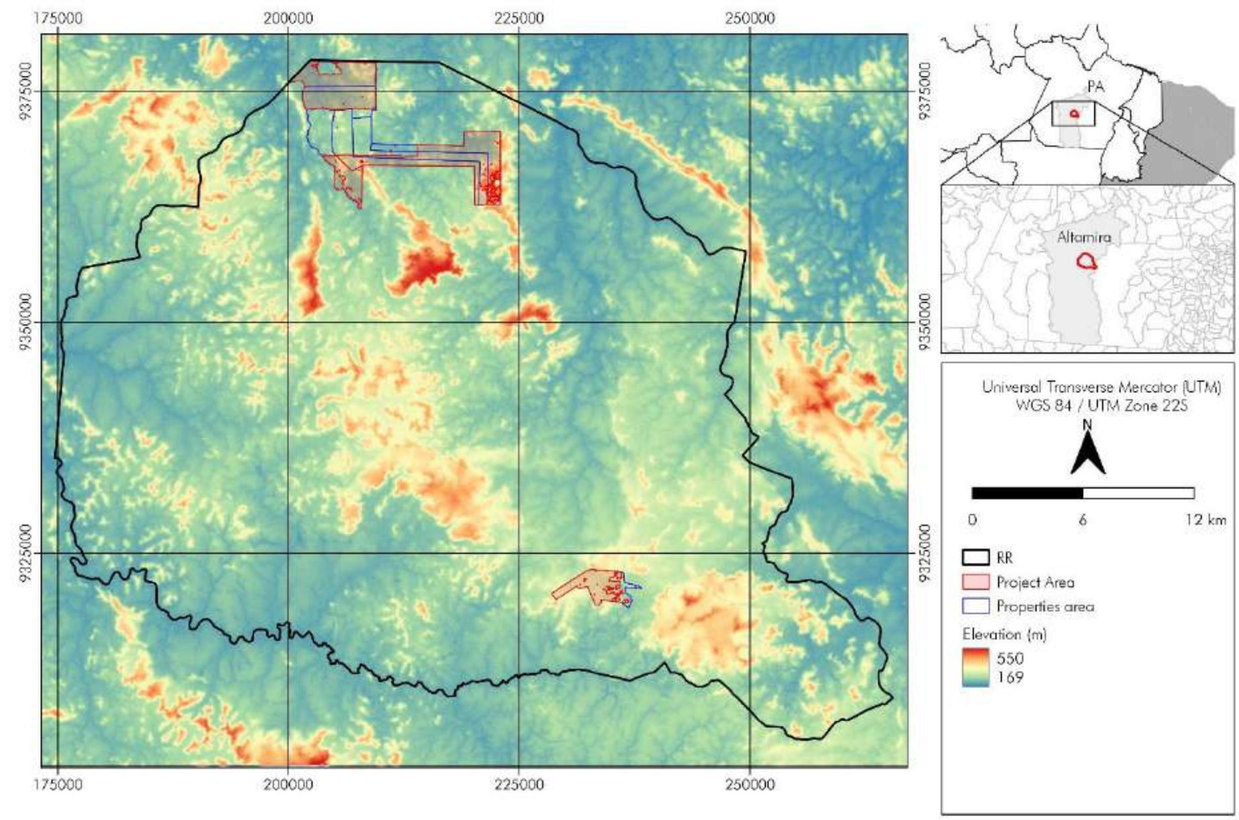


Figure 3.6: Elevation in the Reference Region and Project Area.

Figure 3.7 shows the elevation distributions in the PA and the RR, demonstrating the similarity between them. In this way, 100% of the Project Area has elevations ranging between 185 and 472 meters, while more than 90% of the Reference Region is located at altitudes between 185 and 550 meters, although more than 90% of the altitude distribution is between 185 and 475, Thus, the elevation similarity assessment is greater than 90% and meets the requirements of the methodology. In addition, the average altitude in the Project Area is 352 m, while it is 372.5 m in the Reference Region, which suggests that accessibility would be somewhat easier within the Project Area compared to the Reference Region.

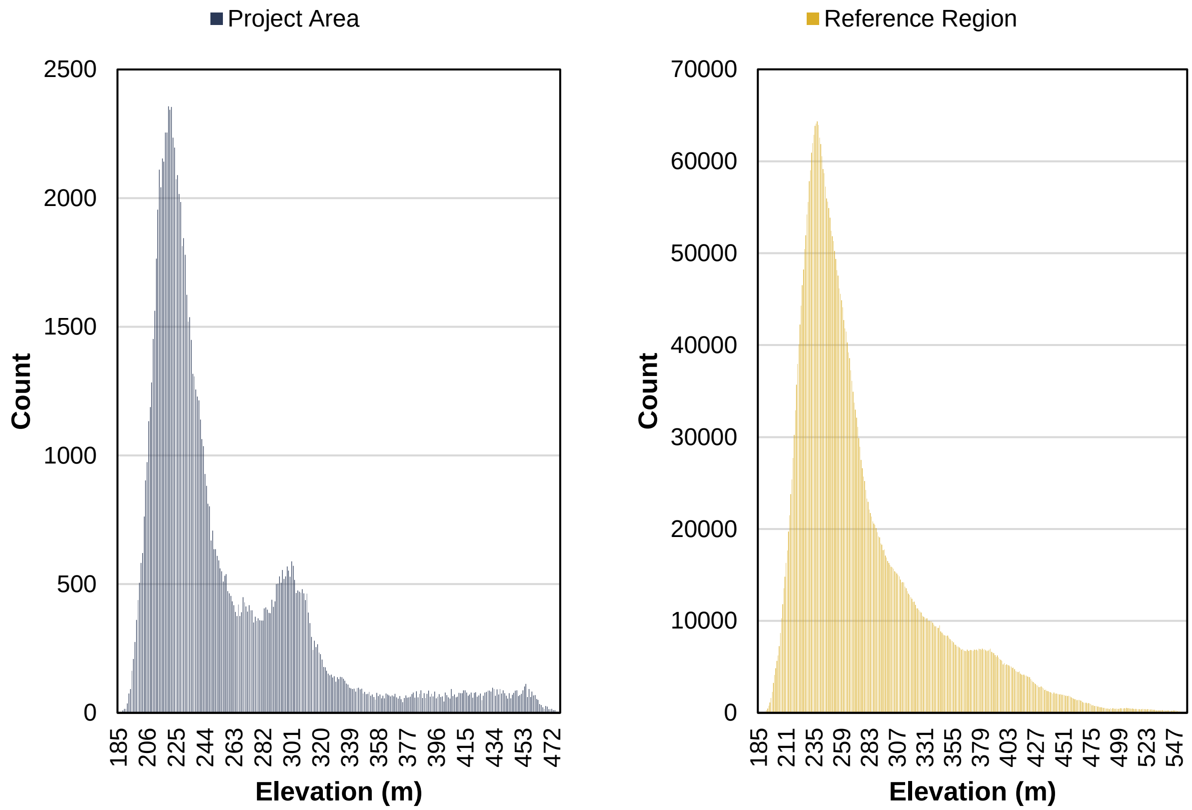
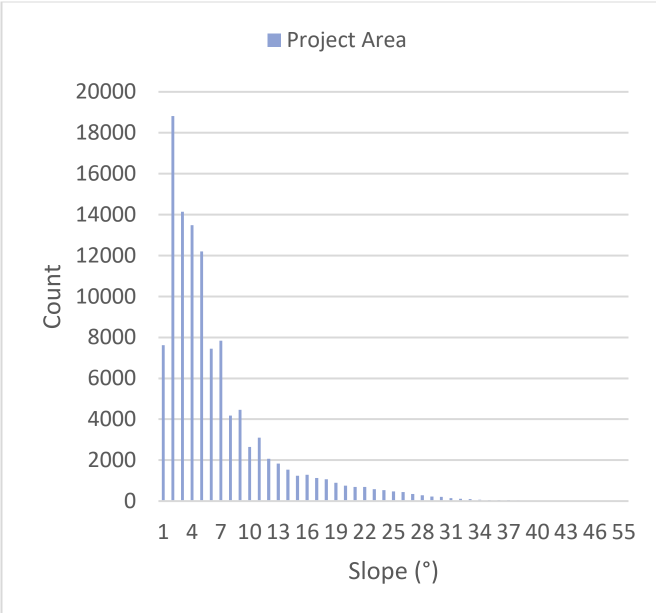


Figure 3.7: Elevation distribution in the Project Area (blue graph, on the left) and Reference Region (orange graph, on the right)

Slope analysis

To classify the slope of the PA and RR, according to the criteria of the methodology, which requires 90% similarity between the two areas, the slope was calculated, in degrees , from a mosaic of digital elevation models, provided by NASA, with a resolution of 30 meters (Farr et al., 2007). Figure 3.8 describes the slope distributions in the PA and the RR, demonstrating the similarity between them, the PA has slopes ranging between 1° to 55°, while the RR is located on slopes of 1° and 57°, although both have more than 90% of the slope distribuition between 1 and 20 degree.



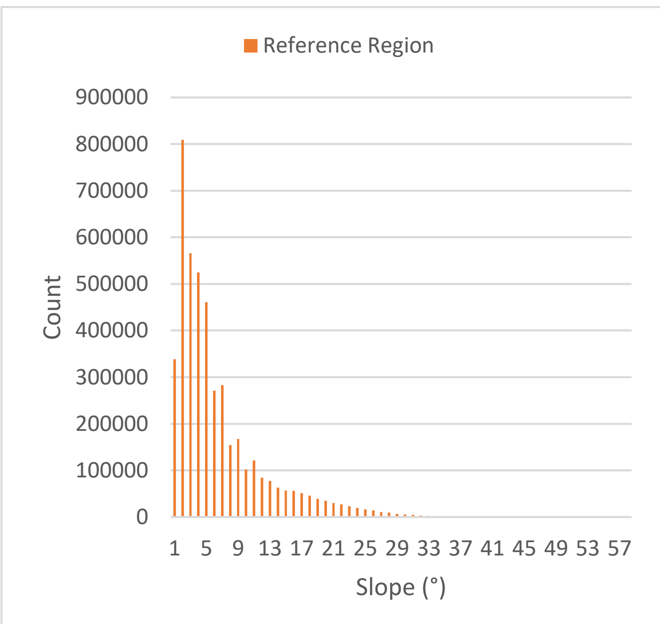


Figure 3.8: Slope distribution, in degree, in the Project Area (blue graph, on the left) and Reference Region (orange graph, on the right)

Thus, the elevation similarity assessment is greater than 90% and meets the requirements of the methodology. In addition, the average slope in the PA is 12.20°, while it is 12.24° in the RR. Thus, the assessment of slope similarity meets methodology requirements.

Socio-economic and cultural conditions

Legal status and tenure of the land

The RR is part of APA Triunfo do Xingu, a sustainable use conservation unit which has no consolidated management or zoning plan. Nevertheless, a large portion of the RR (approximately 80% of its area) is covered by private properties, as shown in Figure 3.8. These areas are governed by the same policies, legislation and regulations, and the Project Area is located within a set of such properties.

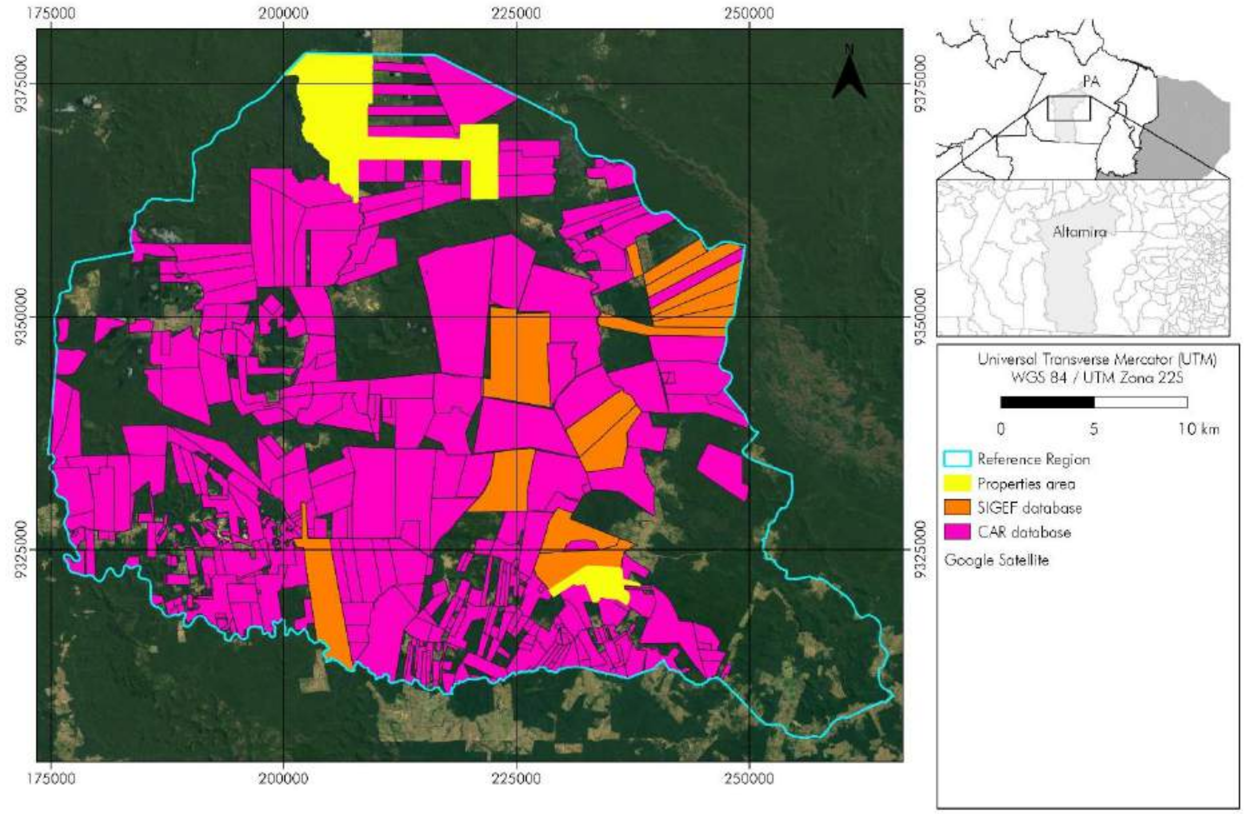


Figure 3.9: Location of private properties showing the legal status and tenure of the land in Reference Region.

Data from SIGEF and CAR were used as a database, filtering out only private properties, and excluding possible registrations with canceled status or areas of collective use. Both bases were considered because they hold the registry of private properties, the main criterion for defining similarity of land tenure and legal status in this topic.

The Land Management System (SIGEF, acronym in Portuguese) was developed by INCRA aiming to promote the management of land information in the Brazilian rural environment. The reception, validation, organization, and regularization of georeferenced data of registered rural properties is carried out through the SIGEF system, which also makes the data publicly available (INCRA, 2023).However, in the state of Pará only ~24 million hectares are currently registered in the SIGEF system, making it one of the Brazilian states with the fewest number of certified rural properties, according to statistics provided by the Territorial Governance Platform (2023). The historical gap in the land titling process and the lack of access to technologies that make registration possible are among the impediments that landowners find when trying to adhere to the system. It is also important to point out that in Brazil there are about

117 million hectares with a "disputed land" status due to issues related to property title, non-fulfilment of environmental legislation, and processes for the demarcation of areas held up in court. (Duarte, 2023)

In view of the above-mentioned limitations to register and certify all Brazilian rural properties in the SIGEF system, the Rural Environmental Registry (CAR) emerges as a complementary tool that helps the analysis of private properties within the TdX RR.

The CAR is a national electronic public registry, mandatory for all rural properties. It was conceived as a database for aiding environmental and economic planning and to allow action to be taken against illegal deforestation. It is important to emphasize that, although self-declaratory, the CAR information is validated by the Brazilian Forest Service to guarantee the veracity and quality of the informed rural data (BFS, 2023).

Thus, the SIGEF and CAR databases are complementary tools to identify private properties in the state of Pará, where the landholding situation is complex, and it is important to consider both to correctly assess the situation of private properties in the RR.

Enforced policies and regulations

Enforced state, municipal and federal policies and regulations governing the rights and duties of private properties and compliance with environmental legislation, such as the Forest Code, in the Project Area were presented in Section 1.14. The PA is located on private property, in the territory of APA Triunfo do Xingu and in the municipality of Altamira. The RR is composed of an expressive mosaic of private properties within the Triunfo do Xingu APA, with at least 90% of its delimitation in the municipality of Altamira, as can be seen in Figure 3.1 Figure 3.9. This being the case, the similarity between the PA and the RR are guaranteed, meeting the requirements of the methodology.

Land use

Current land use, forest, found in 100% of the PA is the majority class of use found in the RR. The projected use class is the class called non-forest (anthropic use) - represented by pasture areas - as can be seen in Figure 3.10 (MapBiomas, 2022) is also found throughout the RR area, meeting methodology requirements.

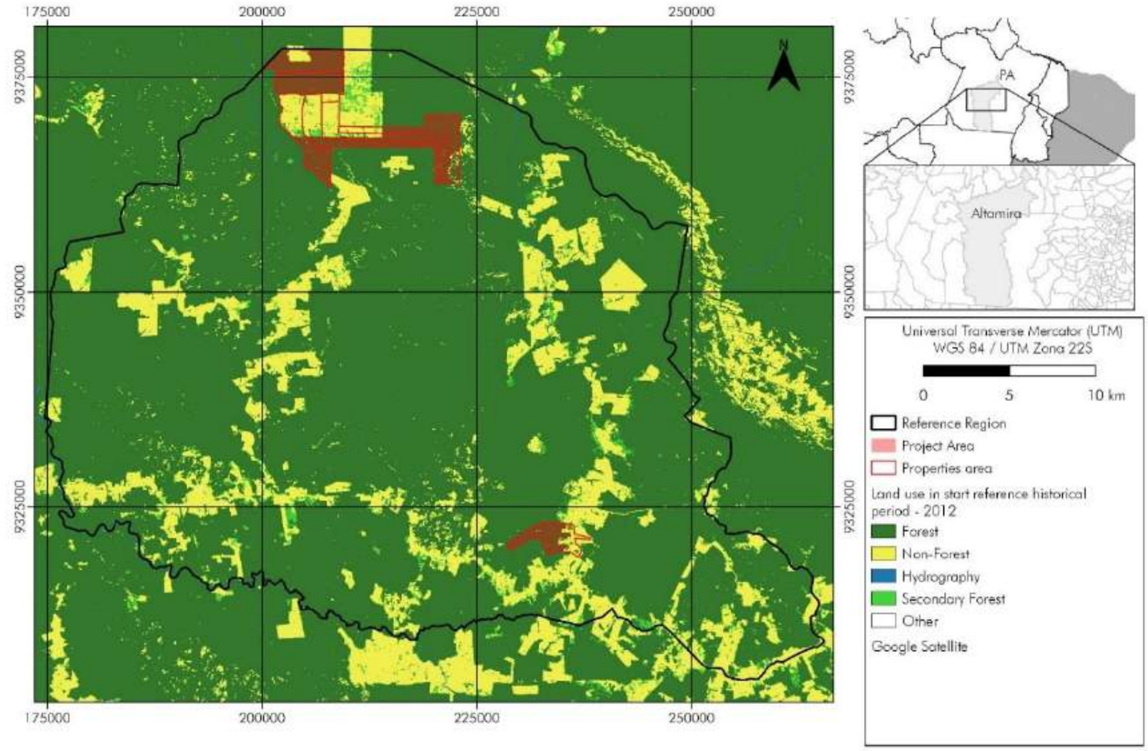


Figure 3.10: Identification of land use classes in the Reference Region and Project Area at start reference historical period.

3.3.4 Leakage belt

To delimit the leakage belt - areas surrounding or adjacent to the project area in which baseline activities could be displaced due to the project activities implemented in the project area -, the Opportunity cost analysis (Option I) was applicated following Approved VCS Methodology VM0015 "Methodology for Avoided Unplanned Deforestation", version 1.1.

Opportunity cost analysis (Option I) is applicable where economic profit is an important driver of deforestation. To test the applicability of Option I, historical records have shown that at least 80% of the area deforested in the reference region (or some of its strata) during the historical reference period has occurred at locations where deforesting was profitable for cattle ranching activities. In this context, literature studies, surveys, and other credible and verifiable sources of information were used to demonstrate the profitability of the main product of deforestation in the region: the cattle (as described in the section "1.13 Conditions Prior to Project Initiation").

Based on opportunity cost analysis (Option I) rationale, leakage can only occur in areas outside the project area where the total cost of establishing and raising cattle and transporting the products to market is less than the price of the products (i.e., opportunity costs are > 0).

The cost map was generated considering the slaughterhouses and urban centers closest to the Project Area – Taboca, Boa Esperança and São Félix do Xingu, all located in São Felix do Xingu in Pará – these points the location of these areas can be seen in the Figure 3.11.

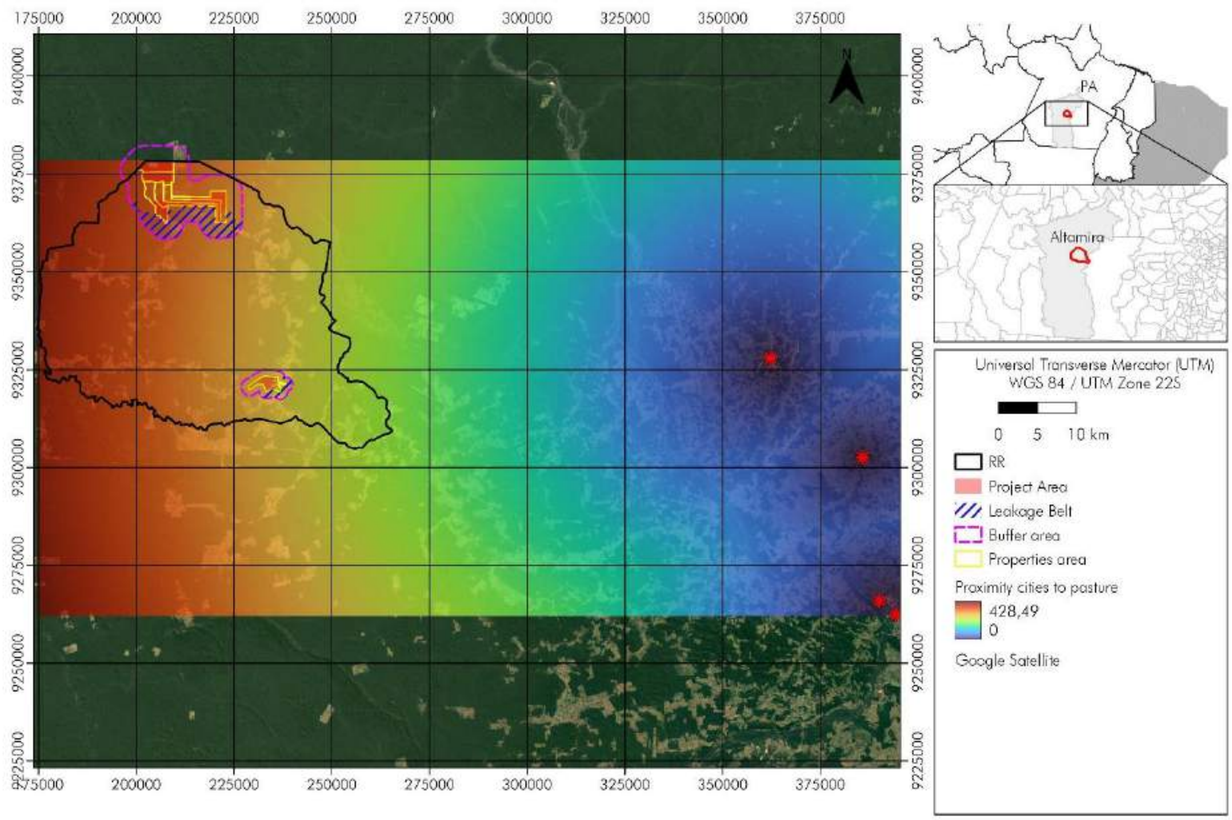


Figure 3.11: Proximity map of cities and pasture areas.

The main land conversion identified in this region is pasture, so a transport cost map from pasture areas to cities was generated. The distance cost map was reclassified considering the value of transport and the fees for loading and unloading cattle - as recommended by Resolution DC/ANTT Nº 5890 (DC/ANTT, 2020), which contains the floor rules for Road Cargo Transport -, where the values adopted were R$ 2.69 per km and R$ 316.03, respectively.

The product sales price map was reclassified with the value of the head of cattle sold in São Felix do Xingu (NotíciasAgrícolas, 2022). Then the map of the average cost of in situ production was reclassified to one head of cattle per hectare (Barbosa et al., 2015). Finally, the potential profitability map was generated based on (Equation 1:

$$PP_{xi} = S\$_x - PC_{xi} \sum_{v=1}^{V} (\mathrm{TDv} * \mathrm{TCv}) \quad \text{(Equation 1)}$$

PP_{xi}	Potential profitability of product Px at location I (pixel or polygon); $/t
$S\$_x$	Product sales price Px; $/t
PC_{xi}	Average in situ production costs for one ton of product Px in stratum i;; $/t
TCv	Average transport cost per kilometer for one ton of product Px on land, river or road of type v; $/t/km

TDv Transport distance on land, river or road type v; km

v 1, 2, 3 ...V type of surface to which transport takes place; dimensionless

The potential profitability map was categorized so that at least two categories were adjacent to each set of properties participating in the project, then a buffer was generated around the properties. The delimitation of the leakage area considered the areas with the highest PPxi within the buffer, and the size of the delimited leakage areas, in hectares, are similar or close to the size of each of the properties participating in the project (Figure 3.12).

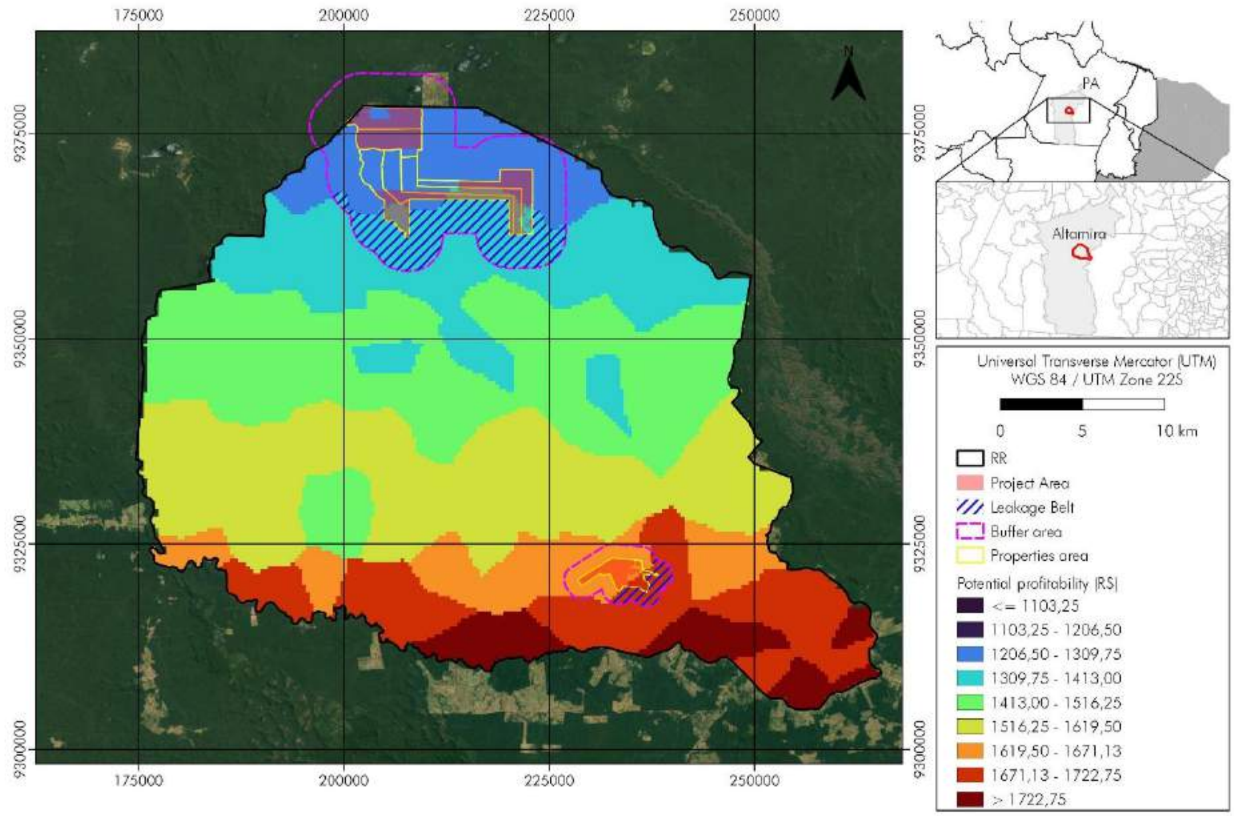


Figure 3.12: Potential profitability in Reference Region, and delimited leakage belt where there are highest values to potential profitability, and their respective buffers.

The Triunfo do Xingu Grouped REDD+ Project, in its first instance, is composed of seven properties. For the delimitation of the Leakage Belt area, the criterion used was the allocation in the immediate vicinity of the project area, and it was prioritized that the Leakage Belt area meet the minimum area requirement of the project area. Thus, two Leakage belt areas were delimited for these instances.

The property called Nossa Senhora Aparecida Farm to the south of the RR has a total area of 1,880.19 hectares, and the Leakage belt 1 delimited around this property was 1,931.14 hectares in a buffer of 1.7 kilometers. The other arrangement of six properties, located north of the RR, total 13,933 hectares, and the Leakage Belt 2 delimited around this property was 14,093.27 hectares in a buffer of 4.1 kilometers

(Figure 3.13). Different buffer values were adopted to meet the objective of delimiting a leakage belt of area approximating the project area and allocated to the most profitable area located around each area.

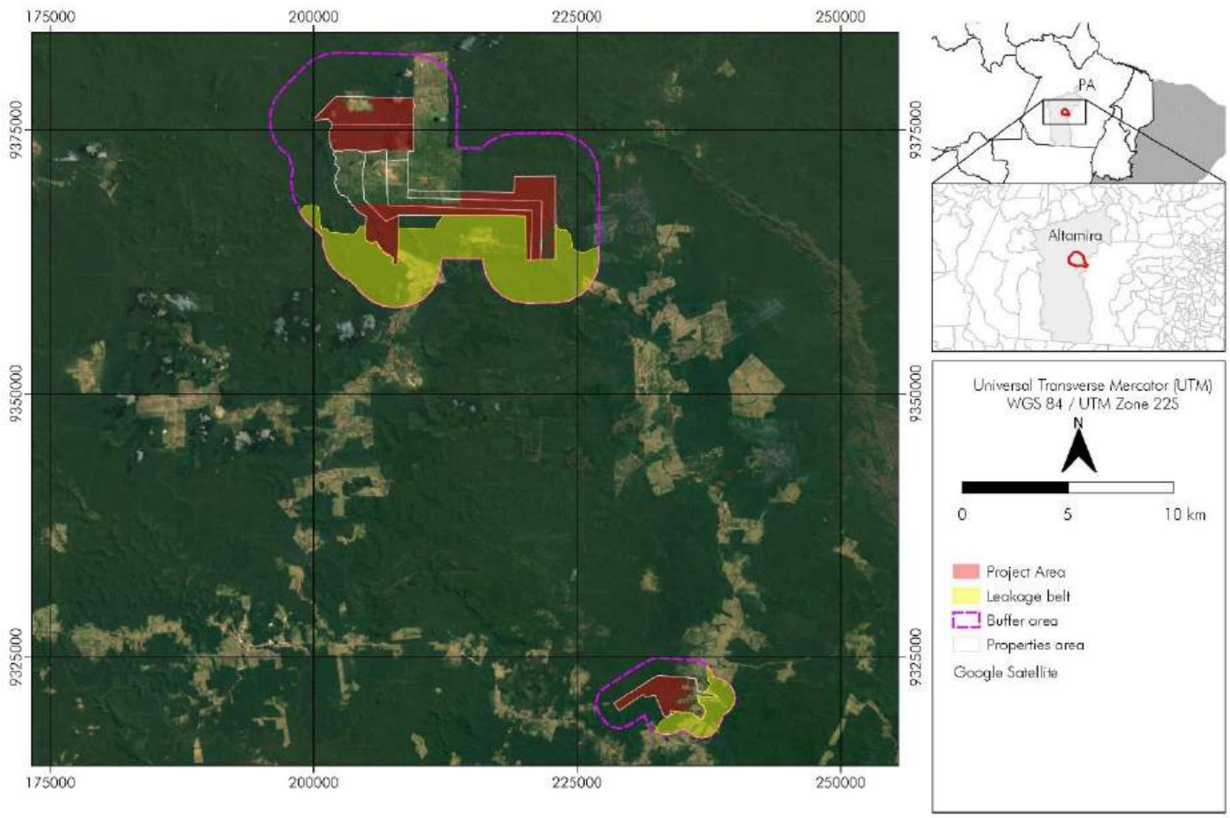


Figure 3.13: Triunfo do Xingu Grouped REDD+ Leakage Belt *and boundaries of the* seven properties.

3.3.5 Leakage belt management

Leakage belt management addresses non-forest areas located outside the project boundary where the Project Proponent intends to implement activities that reduce the risk of leakage in the project scenario. Leakage management involves agricultural, agroforestry, reforestation, education and other activities, as defined in section 4.3, which seeks to include deforestation agents and seek new sources of income that contribute to forest conservation.

3.3.6 Forest

Eligible forests are mature native vegetation over 10 years old according to the MapBiomas classification. The definition of Forest used by the MapBiomas mapping is a broader forest concept and results in a more inclusive mapping, such as areas restored, planting and restoration of native forest over 10 years old. The methodology understands eligible forests, through an empirical classification key based on Mixing Spectral Modeling, as areas with more than 1ha with arboreal vegetation with a height greater than 5m and canopy coverage greater than 30% (Rosa, 2016).

LULC maps created using remote sensing images, according to the VM 0015 methodology, must not exceed one hectare, regardless of forest definition, this being the size of the Minimum Mapping Unit (MMU). Thus, the 30 m resolution LANDSAT images used for mapping and by the MapBiomas Project have the minimum mapping unit defined at 30x30m (0.09ha), and therefore meet the methodology requirement.

3.3.7 Temporal boundaries

- Starting date and end date of the historical reference period

The adopted historical reference period is 31-August-2012 to 30-July-2022.

- Starting date of the project crediting period the AUD project activity

The project has a crediting period of 30 years, from 31-August-2022 until 30-August-2052.

- Starting date and end date of the first fixed baseline period

The first baseline period is from 31-August-2022 to 30-August-2028.

3.3.8 Carbon pools

The applied Methodology considers the six carbon pools listed in the Table below. Their inclusion or exclusion within the boundary of the proposed AUD project activity, as well as the respective justification/explanation, are described in the Table 3.5.

Table 3.5: Carbon pools included or excluded within the boundary of the proposed AUD project activity

Carbon pools	Included/Excluded	Justification/Explanation of choise
Above-ground	Included	Carbon stock change is always significant
Below-ground	Included	Carbon stock change is always significant
Dead wood	Excluded	Excluded for simplification. This exclusion is conservative.
Harvest wood products	Excluded	Not significant
Litter	Excluded	Not to be measured according to VCS Methodology Requirements, 4.0.
Soil organic carbon	Excluded	Not to be measured in conversions to pasture grasses and perennial crop according to VCS Methodology Requirements, 4.0.

The VM0015 methodology considers the two sources of GHG emissions listed in Table 3.6. Their inclusion or exclusion within the boundary of the proposed AUD project activity and the respective justification/explanation, are described in Table 3.6.

Avoiding the conversion of forests to pasture can reduce emissions of N_2O and CH_4 associated with biomass burning, which is used to clear the land. These emissions have been included in emission reduction calculations. However, emissions attributed to fertilizer use, and other agricultural practices that would have occurred if the forests had been converted, were conservatively omitted. In addition, the pasture carbon pool is conservatively considered in the baseline calculation.

There will be no forest management in the Project Area, however, the project emission will be estimated if occurs any unplanned deforestation that cannot be avoided in the project area. In the case of a loss greater than or equal to 5% of previously verified emission reductions and removals due to losses in carbon stocks in pools included in the project boundary that is not planned for in section 3.4, a loss event will be reported to Verra, through the Loss Event Report.

Table 3.6: Sources and GHG included or excluded within the boundary of the proposed AUD project activity

Source		Gas	Included?	Justification/Explanation
Baseline	Biomass burning	CO_2	No	Counted as carbon stock change
		CH_4	Yes	Methane emissions during burning of biomass for land clearance
		N_2O	Yes	Nitrous oxide emissions during burning of biomass for land clearance
		Other	-	
	Livestock emissions	CO_2	No	Not a significant source
		CH_4	Yes	Significant source of livestock emissions
		N_2O	Yes	Significant source of livestock emissions
		Other	-	
Project Emissions	Biomass burning	CO_2	No	Counted as carbon stock change
		CH_4	Yes	Methane emissions during burning of biomass for land clearance
		N_2O	Yes	Nitrous oxide emissions during burning of biomass for land clearance
		Other	-	
	Livestock emissions	CO_2	No	Not a significant source

Source		Gas	Included?	Justification/Explanation
		CH_4	Yes	Significant source of livestock emissions
		N_2O	Yes	Significant source of livestock emissions
		Other	-	
Leakage belt	Biomass burning	CO_2	No	Counted as carbon stock change
		CH_4	Yes	Methane emissions during burning of biomass for land clearance
		N_2O	Yes	Nitrous oxide emissions during burning of biomass for land clearance
		Other	-	
	Livestock emissions	CO_2	No	Not a significant source
		CH_4	Yes	Significant source of livestock emissions
		N_2O	Yes	Significant source of livestock emissions
		Other	-	
		CH_4	No	
		N_2O	No	
		Other	-	In the presence of unplanned deforestation that cannot be avoided

3.4 Baseline Scenario

In this section, we establish the most probable future scenario for the reference region and the project area in the absence of the carbon project. This is done based on an assessment of agents, drivers, and historical patterns of deforestation. The baseline period is the 6-year period between 2022 and 2028, following the project start date. The historical period is the 10-year period prior to the project's start, extending from 2012 to 2022. Here, we also define the "extended historical period" as the 20-year period ranging from 2002 to 2022.

3.4.1 Analysis of historical land-use and land-cover change

Collection of appropriate data sources

Annual land cover maps for the period between 2002 and 2020 were obtained through MapBiomas Collection 6 images (MapBiomas, 2022), MapBiomas is a platform that produces historical maps from Landsat satellite images with 30-meter resolution through a pixel-by-pixel based machine learning classification implemented in Google Earth Engine (GEE). The MapBiomas methodology uses images with minimal cloud cover constructed from a mosaic of Landsat scenes acquired at various months of the year (MapBiomas, 2022).

The MapBiomas classification protocol employs 105 input variables, including original Landsat bands, indexes, fractional and textural information. MapBiomas uses advanced techniques that ensure data accuracy and consistency across space and time. Further information is provided in the ATBD (Algorithm Theoretical Basis Document) document which describes the entire map development, production process, and algorithms used.[87]

By the time our studies were being carried out the land use maps for 2021 and 2022 were still unavailable in the MapBiomas platform. Therefore, they had to be independently produced; this process is described next.

To maintain the same resolution as the maps from the MapBiomas database, both Landsat 7 and 8 Thematic Mapper (Collection 2 Tier 1) and Landsat images were used. The 9 OLI/TIRS (Collection 2 Tier 1) was used to compose the mosaic for 2021 and 2022 leaving less than 1% cloud cover. This dataset contains atmospherically corrected surface reflectance and land surface, at 30 meters spatial resolution and 16-day revisit period. The Tier 1 collection contains images processed with high radiometric and geometric quality. The methodology and surface reflectance calibration coefficients are described by Chander, Markham, and Helder (2009). Variations caused by phenology or changes in solar geometry are minimized by reflectance and cloud shadow corrections.

The software used for processing the 2021 and 2022 images was the Google Earth Engine (GEE, 2022), a cloud-based platform for geospatial data analysis that can be accessed and controlled via a web browser. GEE contains an extensive and freely available data catalog that includes the entire Landsat dataset (USGS/NASA).

The procedure for producing the land use maps for 2021 and 2022 consists of the following steps: importing satellite images with less than 1% cloud cover, composing a mosaic from these images, joining the pixel samples of the areas of forest and non-forest, and then running the Random Forest algorithm (Breiman, 2001) which performs the supervised classification (where there is prior knowledge of the area) of the images. In this last step, samples of pixels of each class are collected and their respective spectral signatures are generated so that the classification of other pixels in the image can be performed. Finally, the results were post-processed by clustering, that is, by replacing isolated pixels with value noise using Unsupervised Clustering methods.

The Random Forest algorithm also outputs accuracy indicators. The accuracy values obtained for the 2021 and 2022 maps were 95.0% and 97.2%, respectively, indicating high-quality classifications. An independent accuracy assessment was also performed using high-resolution satellite images (see the “Map accuracy assessment” section below).

The primary data sources mentioned in this section are listed in Table 3.7, along with additional information.

[87] Annex: 221014_ ATBD_Collection_6_v1_January_2022.pdf

Table 3.7. Data used for historical LU/LC change analysis

Vector	Sensor	Resolution		Coverage (km²)	Acquisition dates* (DD/MM/YY)	Scene or point identifier	
		spatial	spectral			latitude	longitude
Satellite	Landsat TM	30m	0.45-2.35	4250,16	2002-2020*	226	64
Satellite	Landsat 7 e 8 TM	30m	0.45-2.35	4250.16	2021/01/01-2021/12/31	226	64
Satellite	Landsat 9	30m	0.43-2.29	4250.16	2022/07/01-2022/08/01	226	64
* Dates are reported only on a yearly basis, the image is a mosaic							

Summary

As a result of the operations described above, we are left with what we shall refer to as "raw coverage maps". The raw maps for the extended historical period (2002-2022) are stored in matrix format (raster files). To standardize spatial references, all maps have been projected for the UTM and Datum WGS84, Zone 22S projection (EPSG: 32722) and clipped to the reference region. We end this section with a note regarding date tags: As explained, the map for a given year is built from a mosaic of images taken at different months. Therefore, the coverage has no correspondence to a precise date. Nevertheless, for clarity, it is useful to adopt a date convention. Thus, we stipulate that each of the coverage maps corresponds to August 31st of the indicated year. In this way, predicted deforestation between 2022 and 2023, for example, shall be interpreted as deforestation taking place between August 31st 2022 and August 30th 2022, and the yearly intervals we refer to will be aligned with the project start date.

Definition of classes of land-use and land-cover

The classification of MapBiomas (2022) (Collection 6) involves 23 land use and land cover (LU/LC) classes, and 7 of those occur in the reference region (RR). To make our analysis clearer we reclassify the original maps into 4 broader classes according to the scheme in Table 3.8, which also contains a brief description of these simplified classes.[88] The detailed procedures, equally applicable to the 2002-2020 acquire maps and the 2021-2022 independently constructed maps, are explained in the section "Analysis of historical land-use and land-cover change maps". Figure 3.14 displays the distribution of the simplified LU/LC classes at the project start date.

[88] There is one additional class in our maps: the "Other" class. This class is omitted from Table 3.8 and ensuing discussions since it is merely a residual class, consisting of pixels originally classified as "River, Lake, Ocean" in the MapBiomas collection which turned out to be outside the limits of the water shape adopted for defining the water mask. At each year, from 2012 to 2020, only an average of 0.032% of the pixels in the RR are classified as "Other".

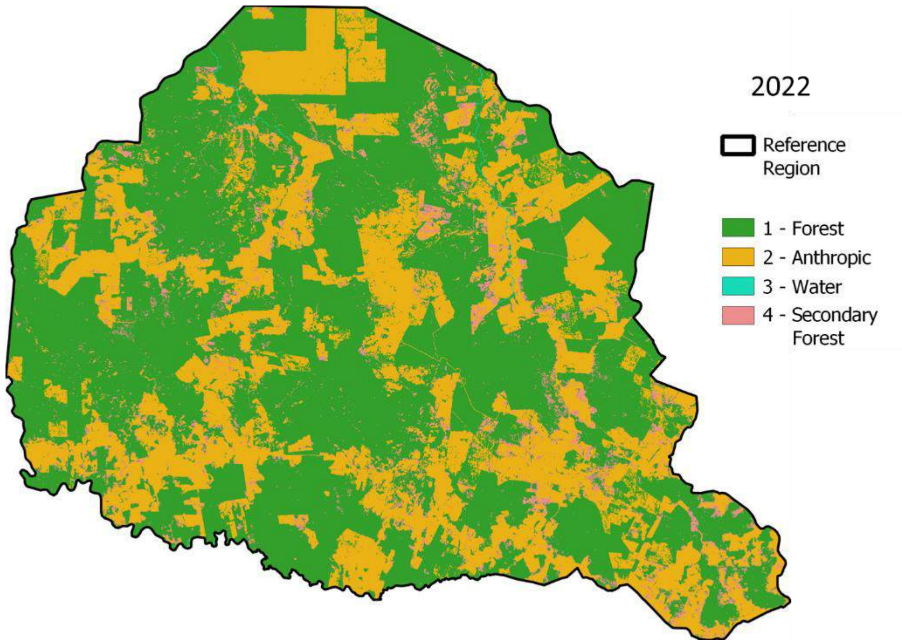


Figure 3.14. Distribution of LU/LC classes in the RR at the project start date.

Table 3.8. LU/LC classes at the project start date within the reference region

Class identifier		Trend in carbon stock	Presence[89]	Baseline activity (LG, FW, CP)[90]	Description
ID	name				
1	Forest	Constant	RR, LK, PA	-	Forest with more than 10 years of age (eligible forests).
2	Anthropic	Constant	RR, LK	-	Combines several categories from MapBiomas: Pasture (93.55%), Grassland (5.64%), Savanna (0.80%), and Other Temporary Crops (0.01%). The values correspond to averages taken in the RR over the period from 2012 to 2020, but they are practically uniform over the years. In our analysis, the Anthropic class is considered equivalent to "pastureland".
3	Water	Constant	RR, LK	-	Rivers and small water bodies. The class is constructed from a mask, meaning water pixels are constant through time.

[89] The Leakage Management (LM) area was not defined since leakage control will be carried out by the proposed activities indicated in sections 1.11 and 4.3.

[90] According to the methodology, only 3 activities need be considered: LG = Logging, FW = Fuel-wood collection, CP = Charcoal production. These have not been considered in the baseline since their occurrence has not been thoroughly evaluated. However, it is known that they are not common in the region, with deforestation usually followed by wood burning.

Class identifier		Trend in carbon stock	Presence[89]	Baseline activity (LG, FW, CP)[90]	Description
ID	name				
4	Secondary Forest	Increasing	RR, LK	-	Forest with less than 10 years of age. Regeneration to fully-grown forest is possible in the historical period.

Table 3.8 also shows the expected carbon stock trend in each class. The trend in the "Forest" class is assumed to be constant since it includes only matured forests whose biomass most likely already reached a stationary value. For the "Anthropic" class, which we shall consider equivalent to "pastureland" (the justification is given below), the carbon stock is practically constant since no significant growth or suppression of vegetation takes place in such areas. On the other hand, the stock in the "Secondary Forest" class, i.e., forests less than 10 years of age, is expected to be increasing – this is also required for consistency since the regeneration dynamics (the transition "Secondary Forest → Forest") is accounted for in our historical maps.

We should mention that the stratification of the "Forest" class into different vegetation types is not necessary at this point. This distinction is made only when predicted baseline deforestation is allocated at future years – the stratum corresponding to every deforested pixel is then identified with the help of a vegetation strata shapefile. Nevertheless, Figure 3.15 is included below, showing the different vegetation types (or forest classes) that were considered.

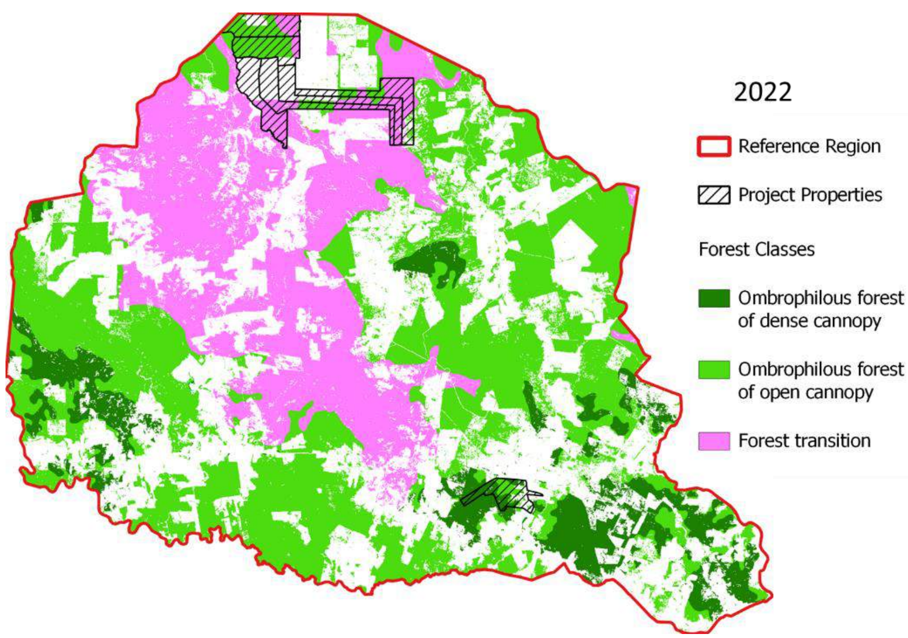


Figure 3.15. Forest classes at forested areas within the RR at the project start date.

Definition of categories of land-use and land-cover change

The possible transitions in the historical maps are schematized in Table 3.9 and the meaning of each transition is explained in

Table 3.10.[91] Persistence-type transitions are omitted since they are trivial. We should mention that in future predictions only the "Deforestation" transition occurs – regeneration is not accounted for in the baseline period.

Table 3.9. Potential LU/LC chance matrix

Transition IDs		Final LU/LC class			
		1 – Forest	2 – Anthropic	3 – Water	4 – Secondary Forest
Initial LU/LC class	1 – Forest	1→1	1→2		
	2 – Anthropic		2→2		2→4
	3 – Water			3→3	
	4 – Secondary Forest	4→1	4→2		4→4

Table 3.10. LU/LC chance identification as transition categories.

Transition ID	Name	Chance in carbon stock	Occurs at	Activities in the baseline case (LG, FW, CP)	Activities in the project case (LG, FW, CP)
1→2 (Forest → Anthropic)	Deforestation	Decrease	RR, LK, PA	-	-
2→4 (Anthropic → Secondary Forest)	Recovery	Increase	RR, LK	-	-
4→1 (Secondary Forest → Forest)	Regeneration	Increase	RR, LK	-	-
4→2 (Secondary Forest → Anthropic)	Erosion	Decrease	RR, LK	-	-

The graph in Figure 3.16 shows the annual number of pixels undergoing the transitions that occur within the RR across the historical period. In this graph, no data is displayed for the "Recovery" and "Erosion"

[91] In this table we omit transitions involving the "Other" class mentioned in Footnote 88 since these are yearly fluctuations that appear due to the water masking procedure. Importantly, "Forest" pixels are never created by these artificial transitions, and they also do not affect the calculation of deforestation rates; deforestation is always identified with the 1 → 2 (Forest → Anthropic) transition.

transitions after 2020 because the independently produced coverage maps of 2021 and 2022 break the continuity of these curves (this has no impact in the "Forest" class).

The transition data clearly shows a steep increase in the annual deforestation rates in the RR region during these last 10 years – this will be a key point in developing our baseline model.

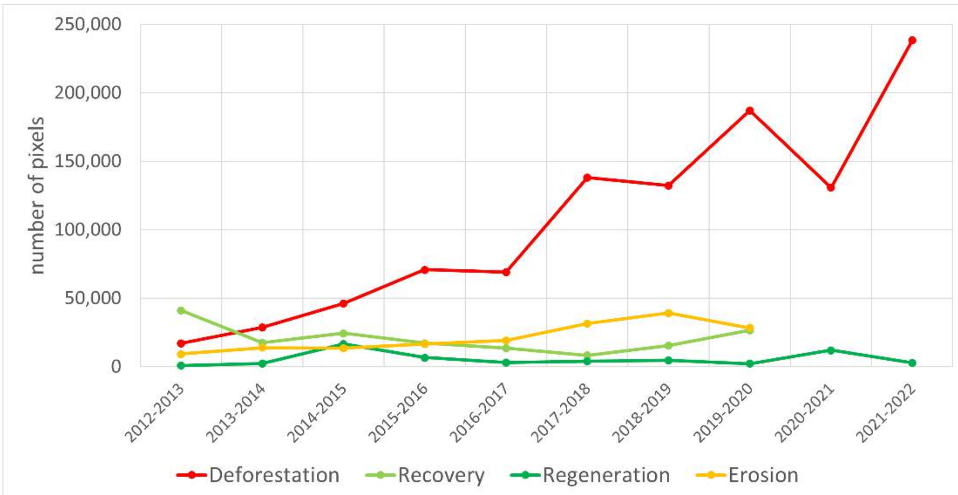


Figure 3.16. Transitions occurring in the reference region during the historical period.

Analysis of historical land-use and land-cover change maps

Because the maps provided by MapBiomas already meet high-quality standards we may confidently employ their classification as a starting point for building our model-oriented, simplified maps. The same is true for the maps of 2021 and 2022. As previously explained, the MapBiomas methodology was replicated in their construction, albeit using a minimum categorization involving only "forest" and "non-forest" classes. In what follows we refer to this set of raster files – that is, the coverage maps from 2002 to 2022 (30m x 30m resolution, EPSG:32272, clipped to the reference region) – as our "raw" database.

Reclassification

The first post-processing operation is a simplification of map categories or reclassification. This requires that two auxiliary maps be prepared beforehand: (i) a "forest age" raster, and (ii) a fixed water mask raster. The "forest age" raster is constructed from the raw maps by implementing the benchmark algorithm described by Silva Junior et al. (2020). This was done in a Python notebook with the help of the Rasterio library (Gillies, 2019). The RR water mask, in turn, is constructed from river shape data – provided by Fundação Brasileira para o Desenvolvimento Sustentável (FBDS)[92] – using standard GIS operations.

Once these preliminary maps are completed the reclassification is performed independently for each year by following the 3 simple steps summarized in Table 3.11.

[92] http://geo.fbds.org.br/

First, the MapBiomas “Forest Formation” class is reclassified as “Forest” and all other MapBiomas classes are temporarily reclassified as “Non-forest”. Next, using the auxiliary “forest age” raster, forests less than 10 years of age at a given year are identified and reclassified as “Secondary Forest”. Finally, the water mask raster is applied to the data set, producing the “Water” class. The remaining non-forest pixels define the “Anthropic” class. The mapping of pixels from one class into another after each step of the procedure is visually conveyed in the table.

Table 3.11. Methodology for simplifying the classification of the original coverage maps.

<table>
<tr><th>Raw Maps</th><th>Step 1</th><th>Step 2</th><th>Step 3</th></tr>
<tr><th>Col. 6 classes within RR (MapBiomas, 2022)</th><th>(temporary)</th><th>(temporary)</th><th>Reclassified maps classes</th></tr>
<tr><td rowspan="4">3 - Forest Formation</td><td rowspan="4">1 - Forest</td><td rowspan="2">1 - Forest</td><td>1 - Forest</td></tr>
<tr><td>3 - Water</td></tr>
<tr><td rowspan="2">4 - Secondary Forest</td><td>4 - Secondary Forest</td></tr>
<tr><td>3 – Water</td></tr>
<tr><td>4 – Savanna Formation</td><td rowspan="5">0 – Non-forest</td><td rowspan="5">0 – Non-forest</td><td rowspan="4">2 - Anthropic</td></tr>
<tr><td>12 - Grassland</td></tr>
<tr><td>15 - Pasture</td></tr>
<tr><td>41 - Other Temporary Crops</td></tr>
<tr><td>33 - River, Lake, Ocean</td><td>3 - Water</td></tr>
</table>

After the reclassification, we may compare the raw and simplified maps to verify the reassignment of the original categories. This verification is particularly important in the case of the “Anthropic” class since we will be relating the Forest ⟶ Anthropic transition to deforestation. The mapping of the raw classes into the “Anthropic” class for selected years is shown in Table 3.12. It is observed that the vast majority of areas composing the “Anthropic” class correspond to “Pasture”, thus justifying our understanding of this class as equivalent to “pasturelands”.

Table 3.12. Verifying the composition of the "Anthropic" class.

Year	MapBiomas (2022)classes mapped reclassified as “Anthropic”			
	Savanna Formation	Grassland	Pasture	Other Temporary Crops
2012	0.93%	6.73%	92.34%	0.00%
2014	0.96%	6.93%	92.11%	0.00%
2016	0.93%	6.05%	93.02%	0.00%
2018	0.70%	4.66%	94.64%	0.00%
2020	0.29%	2.93%	96.68%	0.09%

For reference, Table 3.13 lists the reclassified maps of the historical period.[93] Henceforth the reclassified coverage maps are simply referred to as "forest cover maps".

Table 3.13. List of forest cover maps.

Forest cover maps	
Year	File name
2012	RR1_fcm_2012.tif
2013	RR1_fcm_2013.tif
2014	RR1_fcm_2014.tif
2015	RR1_fcm_2015.tif
2016	RR1_fcm_2016.tif
2017	RR1_fcm_2017.tif
2018	RR1_fcm_2018.tif
2019	RR1_fcm_2019.tif
2020	RR1_fcm_2020.tif
2021	RR1_fcm_2021.tif
2022	RR1_fcm_2022.tif

Forest cover change maps

The second post-processing operation consists in the production of forest cover change maps, most importantly "deforestation maps" indicating areas where Forest ⟶ Anthropic transitions occurred within a specific time window.

To project the quantity of future deforestation the historical curve of annual deforestation must be analyzed, thus annual deforestation maps are required. These are straightforwardly produced by comparing maps of adjacent years, identifying pixels that undergo the Forest ⟶ Anthropic transition, and collecting these pixels in a new class: "6 - Unplanned Deforestation".

For baseline location analysis, two types of accumulated deforestation maps are required. Half-historical-period accumulated deforestation maps, intended for model calibration and validation, and 3-year accumulated deforestation maps, which are used to compute the "distance to recent deforestation" factor maps. The procedure for their construction is the same as that for the annual maps.

For reference, Table 3.14 lists the forest cover change maps employed in the subsequent investigations.

Table 3.14. List of forest cover change maps.

Annual deforestation maps

[93] After the identification of secondary forests, maps prior to 2012 will no longer be needed and therefore are not listed in the table. This is because, as shall be explained later, calibration and confirmation of baseline models was made using separate spatial domains (rather than separate time domains), so that accumulated deforestation maps at 2012 (which would require data from past years as input) are not needed.

Interval	File name
2012-2013	RR1_defor_accm_2012_2013.tif
2013-2014	RR1_defor_accm_2013_2014.tif
2014-2015	RR1_defor_accm_2014_2015.tif
2015-2016	RR1_defor_accm_2015_2016.tif
2016-2017	RR1_defor_accm_2016_2017.tif
2017-2018	RR1_defor_accm_2017_2018.tif
2018-2019	RR1_defor_accm_2018_2019.tif
2019-2020	RR1_defor_accm_2019_2020.tif
2020-2021	RR1_defor_accm_2020_2021.tif
2021-2022	RR1_defor_accm_2021_2022.tif
Half-historical-period accumulated deforestation maps	
Interval	File name
2012-2017	RR1_defor_accm_2012_2017.tif
2017-2022	RR1_defor_accm_2017_2022.tif
3-year accumulated deforestation maps (auxiliary for computing factor maps)	
Interval	File name
2014-2017	RR1_defor_accm_2014_2017.tif
2019-2022	RR1_defor_accm_2019_2022.tif

Figure 3.17 shows the accumulated deforestation maps during the two halves of the historical period. The maps make evident that fact the average rate of deforestation in the second half of the period is much larger than in the first.

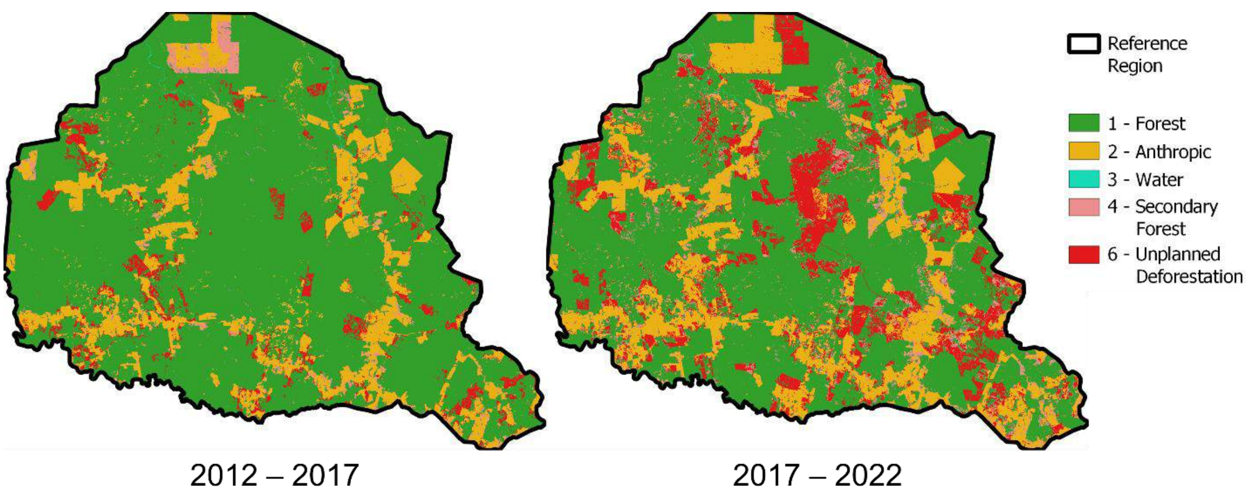


Figure 3.17. Half-historical-period deforestation maps.

Map accuracy assessment

The results of the MapBiomas classification are subjected to a precision assessment, which for the entire Amazon Biome is on average 95% (SOUZA et al., 2020). The precision values obtained year by year can be consulted in the MapBiomas platform (https://mapbiomas.org/accuracy-statistics?cama_set_language=en#content2).

To assess the accuracy of the maps, MapBiomas uses a methodology based on confusion matrices and calculates the percentage of correct answers by the user and the producer, and errors of omission and commission. [94] The methodology is based on the evaluation of a composite sample (from a sample database of ~75,000 samples) where each pixel is manually reassessed by experts every year (SOUZA et al., 2020).

An independent evaluation using high-resolution images from Planet sensors was used to calculate the accuracy for the 2021 and 2022 forest cover maps to meet the requirements of the methodology (< 5 m resolution for ground truthing imagery). The validation assessment was limited to data where high-resolution imagery CBERS 4A (2 meters) was available for corresponding dates. In this sense, it is assumed that the classification algorithm used for the most recent image to achieve the 90% minimum accuracy level of the map product is applicable to the past images and will achieve the same accuracy.

High resolution images CBERS 4A (2 meters), WPM sensor, were used to classify the points; these were obtained from the INPE Catalog database. The period, scenes, satellite, and sensors adopted to validate the 2021 and 2022 maps are listed in Table 3.15. It is worth noting that the panchromatic images were pan sharpening to produce a high resolution (true) natural color image. This process, called sharpening, consists of merging a high-resolution panchromatic (black/white) band with three other color bands. Although the color bands may have a lower multispectral resolution (8 m in this case) the result is a multiband raster with the same resolution of the panchromatic raster (2 m) when the two rasters completely overlap.

Table 3.15. List of the sensors used for the validation assessment.

Vector	Sensor	Resolution		Coverage (km²)	Acquisition dates (DD/MM/YY)	Scene or point identifier	
		spatial	spectral			path	row
Satellite	CBERS 4A	2m/8m	0.45-0.90	4250,16	2022/07/09	216	120/121
Satellite	CBERS 4A	2m/8m	0.45-0.90	4250.16	2021/06/01	216/217	120/121

For the validation, 250 random points spaced by a 5 km radius were generated for each of the images using the “Random points in polygon” tool available in the software QGIS (QGIS, 2022).

[94] From the confusion matrix, measurements were estimated that are related to the confidence of each mapped class. User accuracy, associated with user error when assigning a pixel to one class, when it is some other class, refers to how real the classified map is on the ground. The producer's accuracy, associated with the omission error, which occurs when failing to map a pixel of a class correctly, refers to the quality of the classification scheme. Global accuracy is the estimate of the global correctness proportion of the classifiers.

The sample points were overlayed with the satellite imagens in the reference region (Figure 3.18) making it possible to visually determine the land use of the sample points. For the 2021 and 2022 maps, the sampling points were distinguished in this way, as either “forest” or “non-forest”. It must be emphasized that the forest class was assumed to correspond to MapBiomas (2022) primary vegetation class “3 – Forest Formation” with other types of vegetation being considered as non-forest.

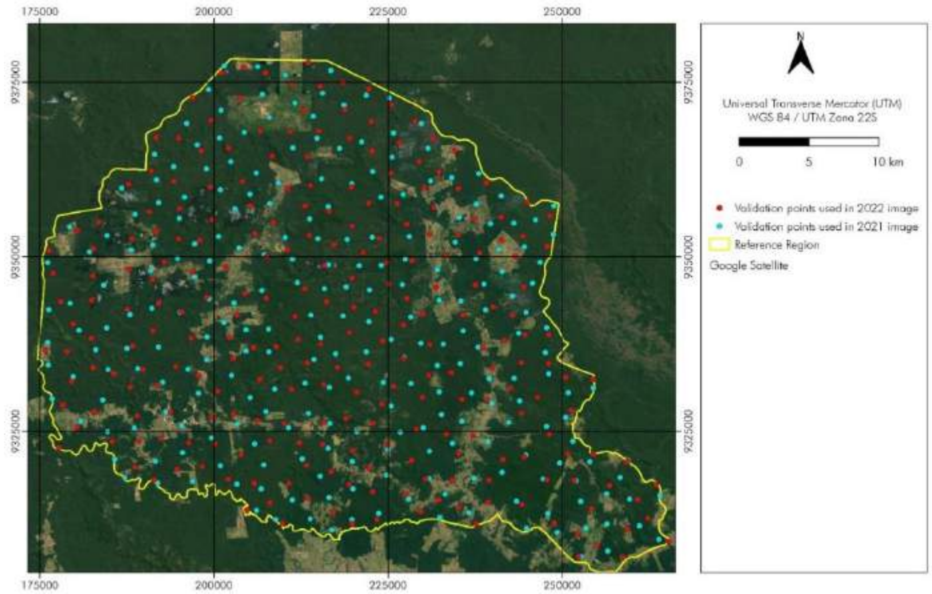


Figure 3.18. Random points used for validation of classified images from 2021 and 2022.

Points were then compared to the forest/non-forest classification obtained for 2021 and 2022 with the help of the Random Forests algorithm, and the accuracy of the classification was evaluated using a confusion matrix, depicted in Table 3.16.

The results of the accuracy analysis for the two classes of the 2021 and 2022 raw maps is displayed in Table 3.17. The global accuracy was 92%, and 94% for 2021 and 2022, respectively. This ensures that all our raw coverage maps meet the minimum accuracy of 90% for each of their classes as set forth in the methodology.

Table 3.16: Confusion matrix for validating the 2021 and 2022 coverage maps.

Class	Confusion Matrix - 2021		Total	Confusion Matrix - 2022		Total
	Non-Forest	Forest		Non-Forest	Forest	
Non-Forest	54000	15300	69300	66600	11700	78300
Forest	1800	153900	155700	2700	144000	146700
Total	55800	169200	225000	69300	155700	225000

Table 3.17: Accuracy assessment for the study area from years 2021 and 2022.

Year		User accuracy (%)	Producer accuracy (%)

	Global accuracy (%)	Forest	Non-Forest	Forest	Non-Forest
2021	92	99	78	91	97
2022	94	98	85	92	96

Preparation of a methodology annex to the PD

An annex has been prepared containing further details on the GIS operations described in this section as well as other products required by the methodology.[95]

3.4.2 Analysis of agents, drivers, and underlying causes of deforestation and their likely future development

According to Instituto Nacional de Pesquisas Espaciais (INPE, 2020), by the year 2020, the Amazon Biome had lost 730,000 km² of its native forests. The most affected part is found in the state of Pará, the second-largest state in Brazil, with a territorial extension of approximately 1,250,000 km². The state encompasses 144 municipalities with an estimated population of 8,777,124 inhabitants, making it the most populous in the amazon region and the ninth most populous in the country (IBGE (2020).

The TdX-I1 project area is located in the Altamira municipality, which extends over 160,000 km² in the central part of Pará. Altamira is the most deforested district in the Legal Amazon as of 2021 (G1, 2021), with an average deforestation rate of over 70,000 ha year^{-1} (TerraBrasilis, 2022). This rate has seen an increasing trend in recent years, as shown in Figure 3.19, and a similar trend is observed for our reference region.

In the following sections, we provide evidence that the main cause of deforestation in the region is the illegal suppression of forests for the implementation of pastureland, which is driven by the economical attractiveness of this activity and encouraged by a lack of law enforcement and overall sense of impunity.

[95] Annex: 221020_ TDX-GIS_DATA_PROCEDURES.zip

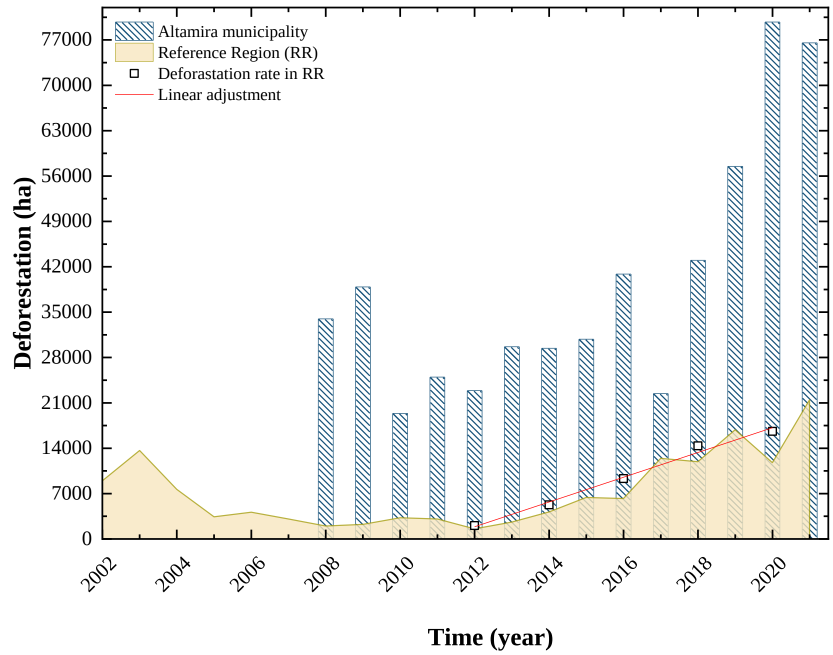


Figure 3.19. A comparison between the annual deforestation curves in the Altamira municipality, where the project is located, and in the reference region.

Identification of agents of deforestation

Livestock activity in the Amazon Biome has expanded almost continuously throughout its occupation history, stimulated by the ever-increasing domestic and foreign market demands for beef and the still relatively low prices of land in the region. The evolution of the livestock size in the municipality of Altamira, displayed in Figure 3.20, reflects this expansion. It is worth noting that the herd size, which seemed to have reached a steady value by 2016, has recently taken on a new growing trend.

Figure 3.20 also shows a comparison between the herd sizes in different municipalities of Pará and Brazil. São Félix do Xingu, a major district adjacent to Altamira, is at the top of both the regional and national ranks, holding around 2.5 million heads of cattle (IBGE, 2021b). The fact that São Félix do Xingu has consistently displayed the highest deforestation rates in Brazil during the last decade (GFW, 2022) is strongly suggestive of the link between deforestation and livestock activities in the region. Given these dynamics, the herd size is expected to increase by up to 41% until 2032 and 66% until 2052 (the project lifetime), according to statistical projections conducted with official IBGE (2021b) data from the 5 years prior to the project start date (Figure 3.20). This significant pace of growth in cattle-related land uses will certainly impose considerable deforestation pressures in the future.

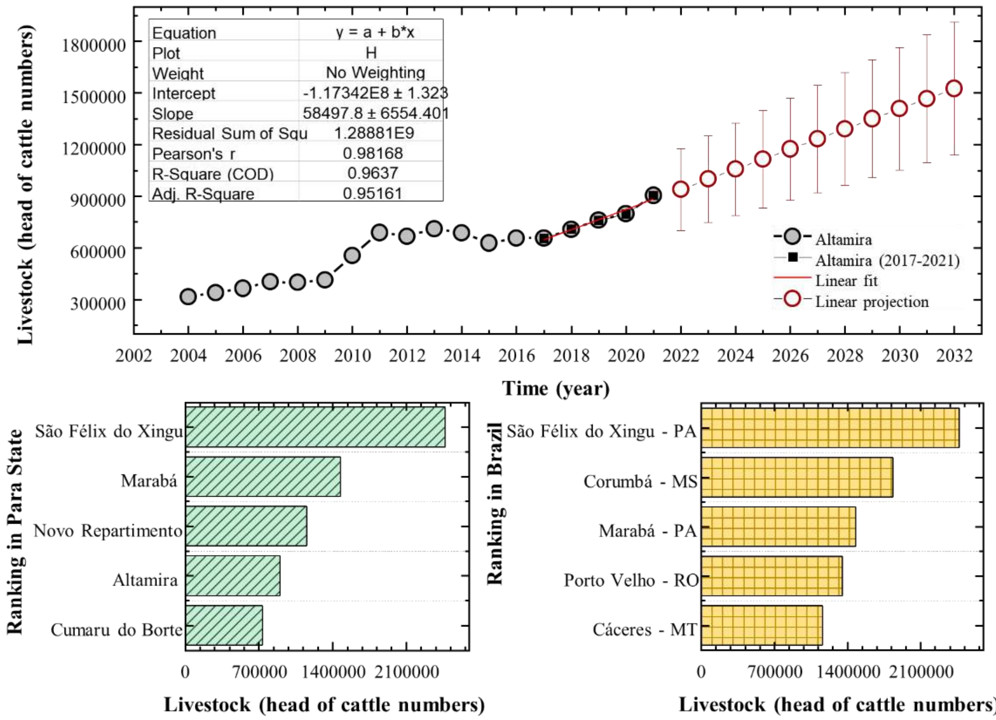


Figure 3.20. Top: herd size in the Altamira municipality as a function of time and linear extrapolation to future years. Bottom: ranking of livestock production in the state of Pará (left) and Brazil (right) by municipality, according to 2021 data (the state abbreviations are: Pará (PA), Mato Grosso do Sul (MS), Rondônia (RO), and Mato Grosso (MT)). Source: IBGE (2021b).

The correlation between livestock activities and forest suppression can be more clearly established by examining historical land cover and land use maps. Comparing coverage maps in subsequent years and studying the transitions between LU/LC classes we find that nearly all (the vast majority) of deforested areas were converted into pasturelands, with no other significant land uses occurring in the reference region. Figure 3.21 shows the evolution of forest and anthropic areas over the years and we observe that as the “anthropic” class, which consists essentially of pasturelands, grows the forest class is suppressed, essentially at the same rate.

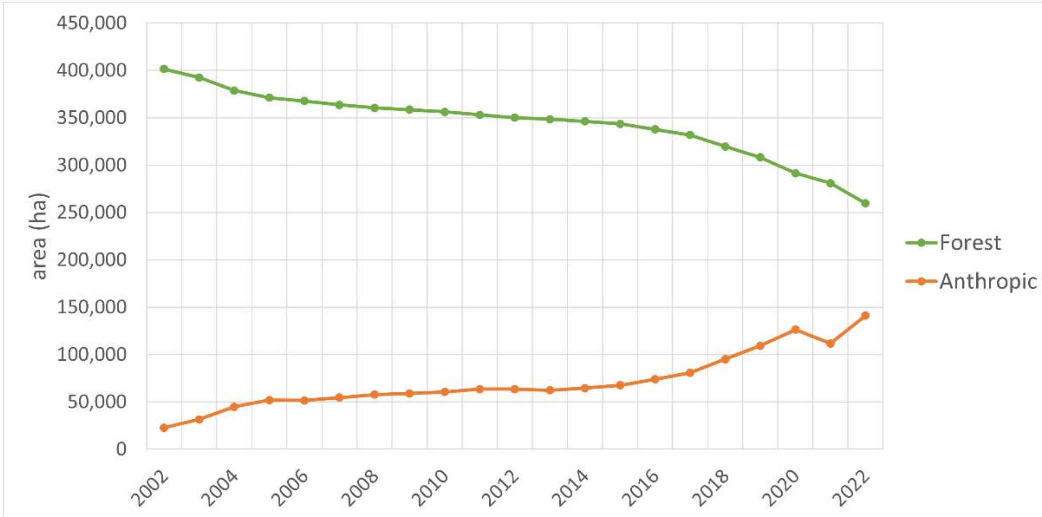


Figure 3.21. The evolution of Forest and Anthropic classes in the project's reference region during the extended historical period (the Anthropic class consists essentially of pasturelands).

From this, we conclude decisively that the main agents of deforestation in the region are the operators of livestock activities. This conclusion is also reinforced by forest fire report data (Figure 3.22) (INPE, 2022c), since the use of fires to "clean" the land to make room for pastures is known to be a common practice in the region, due to the logistical and legal difficulties of using other methods such as tractors. Historically, the fires in the southwest of Pará occurred most frequently in old areas of conversion, demonstrating that the use of fire continues to be a management tool for the maintenance of pastures (Souza, Escada, & Capanema, 2017). It is worth pointing out that the Triunfo do Xingu Conservation Unit, located around the project area and extending across the municipalities of São Félix do Xingu and Altamira, was the Amazon conservation unit that burned the most in August 2020, concentrating 49.60% of the total number of fire spots (INFOAMAZONIA, 2020).

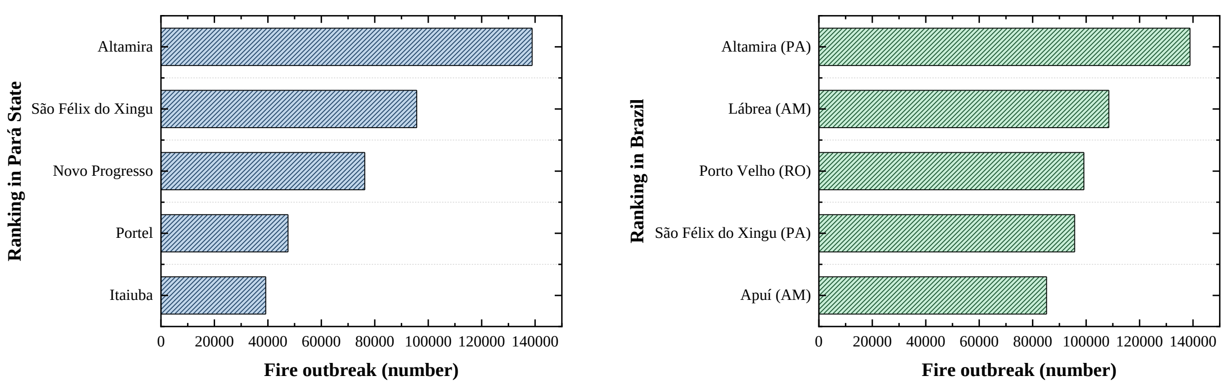


Figure 3.22. Ranking of the fire outbreak (numbers) in Pará State (left) and in Brazil (right) from October 2021 to October 2022.

It should be stressed that livestock activities are not solely advanced by individuals with regularized ownership of their land. Land grabbers or "squatters" ("grileiros") also act as this type of agent in the region. Land grabbing ("grilagem") is a criminal practice that involves invading, occupying, subdividing, and illicitly obtaining the ownership of either public or third-party lands, often resorting to violent means. To claim the invaded land as their own, land grabbers usually provoke fires to clear the area and implement cattle-raising operations. The operation is typically precariously conducted since it serves mainly as a front scheme in their attempt to legitimize their hold of the land. Although land-grabbers may profit from livestock-related activities, their goal is to sell the land to either unsuspicious or complicit buyers, such as large-scale farm owners seeking to expand their activities by acquiring land from squatters – far from being a secondary problem, this is a widespread practice among large property owners in the region (COSTA, 2013). The summary information about the agents of deforestation is described in Table 3.18.

Table 3.18. Identified agents of deforestation: summary.

Information	Description
Name of agent group	Operators of livestock activities
Description of the agent	The group includes: 1) Property owners who deforest their land beyond the limits established by law. 2) Land-grabbers who invade public or private lands and clear their forests to develop a front in the attempt to legitimize their claim of the invaded land. 3) Large-scale property owners who, complicit with the land grabbers' activities, acquire illegally occupied lands in their property's surroundings to expand their livestock activities.
Probable development of the agent's population size	This agent group is related to the increasing demand for cattle livestock. Thus, this estimative can be associated with the herd size projected based on the last five years (2017-2021). Given these dynamics, the herd size is expected to increase by up to 41% until 2032 and 66% until 2052 (the project lifetime), according to statistical projections conducted with the official data from IBGE (2021b) (Figure 3.20). This significant pace of growth in cattle-related land uses will certainly impose considerable deforestation pressures in the future.
Relevant statistics associated with the agent	The average annual forest decline rate is 5% between 2017 and 2021 in the RR with a high deforestation rate of 21,459.60 ha in 2021. The RR Forest area decreased to around 34% from 2002 to 2021, being that 19% occurring in the last five years (Figure 3.19). These deforestation areas are directly related to the livestock activities in the RR region according to Figure 3.21. There are no other significant land uses within the deforested lands in the Reference Region. This corroborates the strong activity of cattle ranchers in the Reference Region. Thus, it is confirmed that virtually all deforestation in the Reference Region is attributed to the group of deforestation agents related to the conversion of forest to pasture for cattle ranching.

Identification of deforestation drivers

Once the deforestation agents have been identified we now proceed to examine their motivations and the factors determining which forest areas are more likely to be suppressed in view of their activities, that is, the “deforestation drivers” that govern the quantity and location of deforestation in the region of interest.

Drivers explaining the quantity of deforestation

Economical attractiveness of livestock farming

We may establish directly that the primary driver is the economical attractiveness of livestock farming. The implementation of the extensive type of cattle ranching practiced in most of the Pará state is relatively straightforward and requires only low levels of capital investment (Imazon, 2015; Láu, 2006; Rivero, Almeida, Ávila, & Oliveira, 2009). Furthermore, it is an activity with high liquidity and short-term revenues. It is also of low risk since the global demand for cattle products has been steadily increasing over the years. (WWF, 2018) This provides sufficient incentive for the local operators of livestock activities to continue to engage in illegal deforestation for land clearance. The fact that the herd size within the Amazon Biome grew from 130 to 220 million heads between 1985 and 2020, more than 150% in 35 years (IBGE, 2020), provides a measure of the development of livestock activity in the region and, as evidenced by the data projection plotted in Figure 3.20, there is no indication that this trend will slow down in future years. Since project measures can't influence market demands we expect the deforestation pressure imposed by this driver to remain active throughout project years.

The overall perception of impunity

The non-compliance with environmental laws, the intense activity of land grabbers, and the willingness of large-scale farmers to partake in and even boost such illicit schemes – these are all enabled by inapt governance concerning land ownership and a generalized lack of law enforcement in the amazon region, as will be discussed as will be discussed in more details in the subsection “Land-use policies and their enforcement” (where pertinent references on the subject can found).. Thus, the overall perception of impunity and the perspective of turning high profits from criminal enterprises can also be listed as a significant deforestation driver in the region. Unfortunately, there is no indication on the part of governmental institutions that effective measures will be taken to alleviate this situation, so this driver is also expected to persist during project years. While project measures may have a positive impact concerning this issue, its effects would be limited to the immediacies of project properties.

Drivers explaining the locations of deforestation

The drivers that control the location of deforestation can be identified by cross-examination of coverage maps and maps describing land jurisprudence, accessibility, and landscape factors. The key drivers and the way they were incorporated into our studies are described below.

Presence of fully protected conservation units

We observe that although deforestation is outspread within the Triunfo do Xingu APA (a sustainable use conservation unit), it seems to be contained at its frontiers with Parque Nacional da Serra do Pardo and

Estação Ecológica da Terra do Meio, both of which share the status of fully protected conservation units. Clearly, deforestation is inhibited inside the fully protected units, as evidenced by geospatial data (MapBiomas, 2022). Therefore, the presence of land with this type of jurisdiction is an important driver for predicting the location of deforestation (by exclusion), so much so that we chose to remove these areas from our reference region, as explained in section 3.3. Conservation units constantly face threads, notably from infrastructure (mainly transport and energy) and mining projects. (WWF, 2019) Whether such threads may lead to the downgrading or downsizing of a given unit is hard to predict, since that depends mostly on political decisions. For now, it is reasonable to assume that the fully protected status units neighboring the RR will continue to exist and act as barriers for deforestation.

Distance to roads

Distance to roads is immediately recognized as a driving factor when the deforestation maps are overlayed with road infrastructure data. (Jaffé, 2021) Roads not only provide access to newly occupied areas (where deforestation tends to be more intense) but are also important for transporting the products of activities that cause deforestation. Moreover, since production costs scale with the distance to major roads forest areas closest to roads are under greater threat. Distance to roads is taken as a mandatory variable in all the analyzed baseline models.

Proximity to urban areas

For similar reasons, proximity to large cities also acts as another driver of the locations of deforestation. (Jaffé, 2021) Visual inspection of the historical coverage maps reveals that deforestation in the Triunfo do Xingu APA broadly followed an east-to-west movement, first concentrating in the surroundings of São Félix do Xingu, to the east, then hobbling towards the west as the former areas became saturated with anthropic activities. Proximity to cities was employed as a variable in the opportunity-cost analysis leading to the definition of the project's leakage areas, as discussed in section 3.3.

Distance to water

Water is an essential resource to develop any kind of rural activity, making the distance to water a variable to be considered in our baseline models. It would be reasonable to expect that proximity to rivers should favor deforestation, but this is not the case according to our statistical analysis. A possible explanation is that most of the forest areas adjacent to water are found at the border between the reference region and the conservation unit Estação Ecológica da Terra do Meio, and the transition probability in these areas is likely being influenced by the presence of the fully protected unit.

Distance to anthropic areas and distance to recent deforestation

It is well known that future deforestation is likely to occur in the vicinities of already deforested areas. The historical deforestation observed in the reference region matches this pattern -- this is thoroughly confirmed by the statistical evidence integrated into our baseline risk maps. We employ two types of variables that capture this behavior: distance to recent deforestation and distance to anthropic areas. The first is used in our baseline models and the second is used to define risk zones within the reference region (section 3.4.3).

Elevation and slope

It is straightforward to identify terrain slope and elevation as important predisposition factors for deforestation. Steep terrain is generally less suitable for conversion than flatlands, (Guizar-Coutiño et al, 2022) and the relative risk for areas at different slope classes, as determined by statistical methods during the construction of our models, corroborates that proposition. Furthermore, comparing elevation and land use data we find that, historically, high-altitude areas have been much less deforested than low-elevation areas. This led us to adopt elevation as one of the criteria used to define risk zones in our reference region (section 3.4.3). The reasons why highly elevated and steep areas are less prone to being deforested are mostly related to accessibility issues and difficulties for handling heavy machinery in that sort of terrain; these areas also tend to be farther away from existing infrastructure such as roads and cities.

Identification of underlying causes of deforestation

Deforestation agents act according to conditions set in a broader context involving social, political, and economical factors – these constitute the underlying causes of deforestation to be discussed in this section. For the TdX-I1 Project – and, in fact, for the entire state of Pará – the main underlying causes can be traced to inadequate land-use policies, worsened by a lack of law enforcement and poverty.

Land-use policies and their enforcement

According to the Brazilian Forest Code, landowners in the amazon region are required to have 80% of their property area covered with forest. However, the lack of law enforcement by local authorities, alongside an increasing need for pastureland has created a scenario of almost complete disregard for this mandatory provision. (COSTA, A. L. S. D. 2013) Moreover, the prevalence of scarcely populated areas and the vast distances to be covered for proper surveillance makes tracking illegal activities extremely difficult and the control of unplanned deforestation has proven to be ineffective so far. Only 45% of deforestation in the region is detected in such a way that inspectors can respond promptly, and the violators are made accountable only in 24% of the occurrences. Among these, 26% are judged in the first instance, a process that may drag on for years (three years on average, according to data obtained from the analysis of 11,823 assessments from 2008 to 2013). Fines, seizure of products involved in environmental violations, the embargo on deforested areas, and blocking of assets are some of the possible punishments. However, the actual application of these sanctions under current policies is often slow and ineffective. Therefore, the economic advantage obtained by exploring illegal activities is perceived as greater than the punitive risk (Margulis, 2003; UnBCiência, 2016; WWF, 2022). Given such circumstances, we may confidently state that inadequate policies and lack of law enforcement are and will continue to be underlying causes of deforestation in the region during the project's lifetime. Although the project cannot solve this deeply rooted problem, it can set an example of a profitable and sustainable land-use alternative in the region and encourage neighbors to adopt similar practices.

Poverty

In 2020, the average monthly salary in the municipality of Altamira was about 2.1 times the minimum wage (or approximately R$ 2,200) with 13.4% of its total population formally employed. In terms of these indicators, Altamira performs relatively well when compared to other municipalities in the state of Pará, or even in Brazil. However, by 2010, 41.5% of its population lived in households where the average monthly income per capita was only half a minimum wage or less, a situation that likely has not changed. (IBGE, 2020) This metric, depicted in Figure 3.23, shows that the district of Altamira faces poverty issues. Poverty has a major impact on deforestation since the main agents (cattle ranchers, operationally supported by loggers and land-grabbers) can easily recruit cheap manpower, consisting of workers struggling to sustain their families. Therefore, poverty is recognized as an underlying cause of deforestation which will persist during the project's lifetime. While the project activity cannot solve the poverty issue, it seeks to provide new jobs for local workers who will be able to support their families through a legal and sustainable initiative.

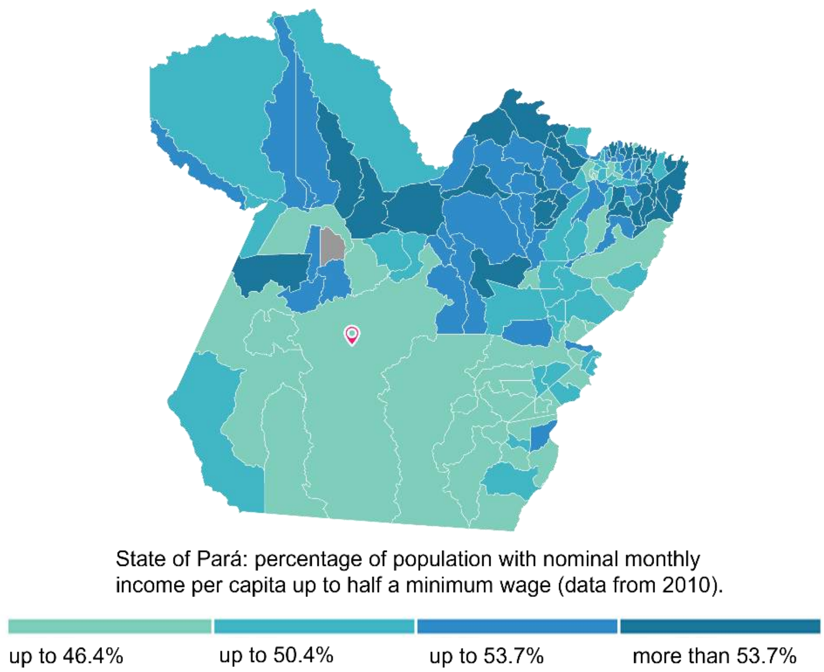


Figure 3.23. Map showing the metric "percentage of the population with monthly income per capita of half a minimum wage or less" for each of the municipalities in the state of Pará (adapted from IBGE).

Analysis of the chain of events leading to deforestation

In light of the points raised above, we may now identify the chain of events that lead to deforestation in the project region and its surroundings. It can be summarized as follows: The high market demand for livestock products and the availability of cheap labor due to prevailing poverty makes cattle ranching an economically attractive activity in the region. This creates pressure for converting forest areas into pastureland. At the same time, policies and laws intended to prevent widespread deforestation within private properties are hindered both by difficulties associated with the monitoring of the region and by a slow and ineffective juridical system. This makes illegal deforestation to be generally perceived as a low-risk activity, encouraging land-grabbers who engage in criminal methods to take hold of land seeking to profit from its subsequent sale, destroying the forest in the process. To aggravate, large-scale property owners often partake in this illicit scheme, acquiring land from squatters to expand their activities into neighboring areas. Finally, most of the pasture areas in the state of Pará tend to be poorly managed, with no concern for the soil's health, and once the soil is degraded new pasture areas must be opened thus propagating further deforestation.

In this conjuncture, an investigation of historical deforestation patterns suggests that the only factors that seem to partially deter deforestation outside fully protected conservation units are those associated with terrain constraints, such as the presence of high elevation and high declivity areas, inadequate for cattle raising.

There is no indication that any of these causal links are likely to change in the future and the fate of the region is expected to correspond to a scenario where forest areas are suppressed up to the saturation point when anthropic activities reach their limit due to the abovementioned landscape constraints.

Conclusion

The analysis carried out in this section leads to conclusions that are consistent with literature and field studies, and all assertions related to historical land use and land cover data are verifiable by either direct inquiries or standard statistical methods.

In particular, the increasing trend of annual deforestation rates in the reference region observed in recent years can be understood as a consequence of the dynamics between deforestation agents and their motivations as laid out in the chain of events discussed above. At the same time, there is no indication that the behavior of such agents and the circumstances enabling that behavior are likely to change in the future.

Therefore, there is **conclusive evidence** that the baseline deforestation of the TdX-I1 project will continue to follow an overall **increasing trend**.

3.4.3 Projection of future deforestation

In this section, we combine historically obtained data and the knowledge gathered in previous sections regarding deforestation agents and drivers to predict how future deforestation patterns will most likely evolve in the reference region. To this end, we first establish the quantity of future deforestation by extrapolating the current trend; then we apply statistical techniques to assess the risk at each pixel of the RR so that the locations of future deforestation can be determined.

Projection of the quantity of future deforestation

The dynamics leading to deforestation – the chain of events resulting from the motivations and actions of the identified agents – is the same across the reference region. Therefore, we develop our baseline models treating the RR without stratification. This means that the quantity of future deforestation will be projected based on the historically observed rates of the RR.

Table 3.19 shows the annual deforestation in the RR during the historical period as computed from our forest cover change maps. The table also shows the 2-year averaged values used in the next section. The trend is evidently increasing.

Table 3.19. Historical deforestation observed in the reference region.

Period	RR deforestation (annual) (ha)	Period	RR deforestation (2-year average) (ha)
2012-2013	1,541.43	2012-2014	2,061.00
2013-2014	2,580.57		
2014-2015	4,152.69	2014-2016	5,267.25
2015-2016	6,381.81		
2016-2017	6,214.23	2016-2018	9,323.91
2017-2018	12,433.59		
2018-2019	11,914.38	2018-2020	14,374.35
2019-2020	16,834.32		
2020-2021	11,767.14	2020-2022	16,613.37
2021-2022	21,459.60		

Selection of the baseline approach

To project the future trend, we must first find a mathematical expression that fits the historical data. To obtain a smoother curve, we take 2-year-interval average values of the annual deforestations. Figure 3.24 shows a bar graph with the averaged values (also displayed in Table 3.19).

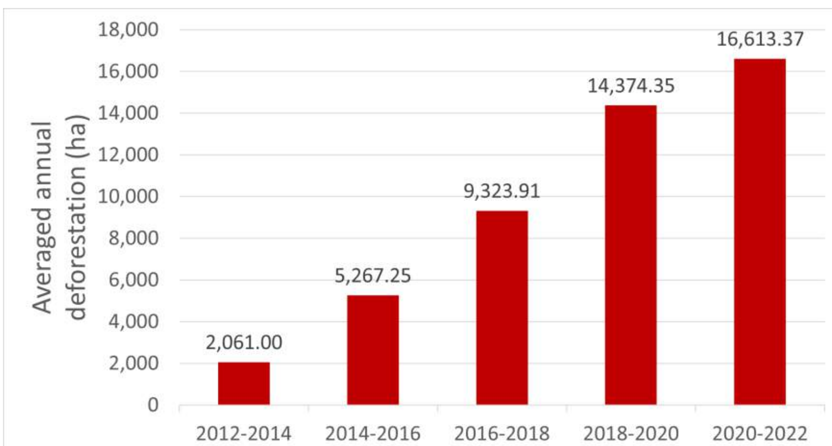


Figure 3.24. Averaged annual deforestation in the reference region during the historical period.

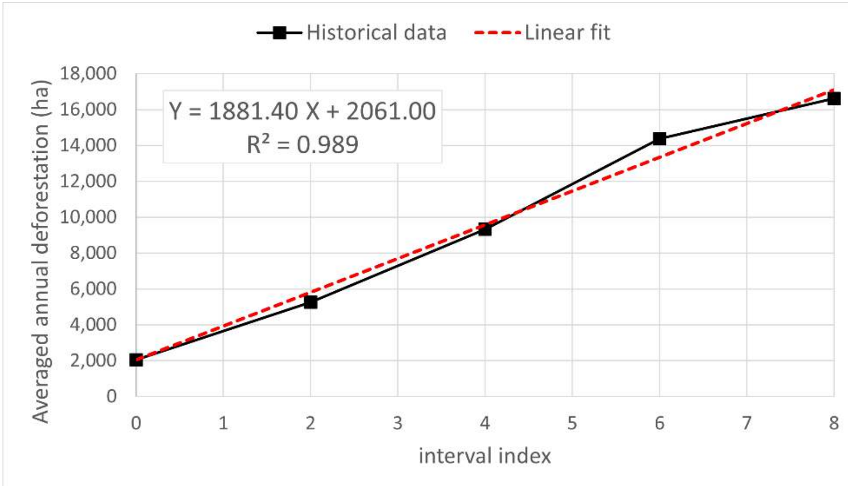


Figure 3.25. Historical deforestation in the reference region and linear fit.

We find that the data can be almost perfectly described by a linear function, [96] as shown in Figure 3.25. This result leads us to the following conclusion:

- The deforestation rates measured in the reference region **reveal a clear trend** and this trend is an **increase in the deforestation rate.**

Furthermore, as stated in Section 3.4.2:

- **Conclusive evidence** emerges from the analysis of agents and drivers explaining the increased trend and making it likely that **this trend will continue in the future.**

Therefore, in accordance with the methodology, we select the **"time function approach"** to construct the baseline model.

Quantitative projection of future deforestation

Under the "time function approach", the quantity of projected future deforestation in the RR does not follow from a direct extrapolation of the linear trend found in the previous section. Rather, the linearly increasing trend is assumed to last only for a certain period. The deforestation rate then reaches a plateau, where it persists with a constant value for a certain number of years and, finally, steadily decreases. The duration of each of these three different phases – increasing, constant, and decreasing – is determined by the extension of forest areas considered of optimal, average, and sub-optimal suitability for conversion, since deforestation will be assumed to occur sequentially in these areas, that is, deforestation will first consume the optimal area, then the average area, and lastly the suboptimal area. For simplicity, we shall refer to these sequential areas as "risk zones".

Projection of the annual areas of baseline deforestation in the reference region

[96] The linear fit was performed setting the value of the intercept so that the trend line matches exactly the observed deforestation in the first interval (2012-2014, interval index = 0).

To arrive at the target baseline deforestation curve, we therefore must first delineate the risk zones within the reference region. According to the methodology, these zones should reflect the constraints faced by deforestation agents – in our case, livestock operators – when carrying out their baseline activities. This allows us to add some intuition to our baseline models and avoids us having to rely entirely on statistical methods to make our predictions.

The criteria adopted for the definition of the risk zones were based on two of the driver variables previously discussed: terrain elevation and distance to anthropic areas. The criteria are derived from a careful examination of deforestation patterns in the reference region, being also consistent with what is expected from the behavior of the deforestation agents.

When anthropic areas (pastureland) are overlayed with terrain elevation data it is possible to observe that, up to the project's start date, they have been concentrated on low-altitude lands (left map of Figure 3.27), suggesting that the highlands within the RR act as a barrier against deforestation. This can be quantified by inspecting the elevation histogram of anthropic pixels (left histogram of Figure 3.26). We find that 91.4% of anthropic areas are located below 330 meters of altitude, indicating a clear preference for low ground by cattle ranches. This makes sense for low grounds are generally more accessible, facilitating transportation of resources and products. Therefore, we define the "Low-risk zone" – or area of sub-optimal suitability for conversion – as the areas located at an elevation higher than 330 meters.

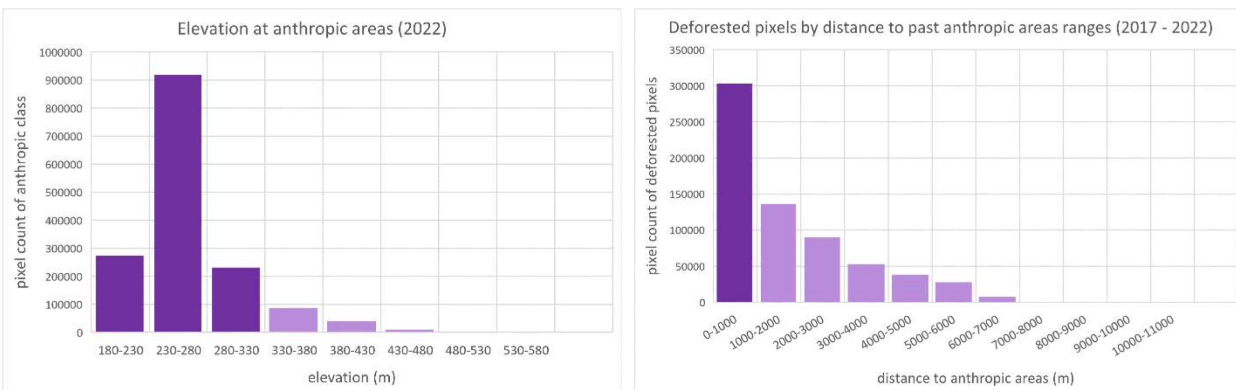


Figure 3.26. Criteria used for defining risk zones (histograms).

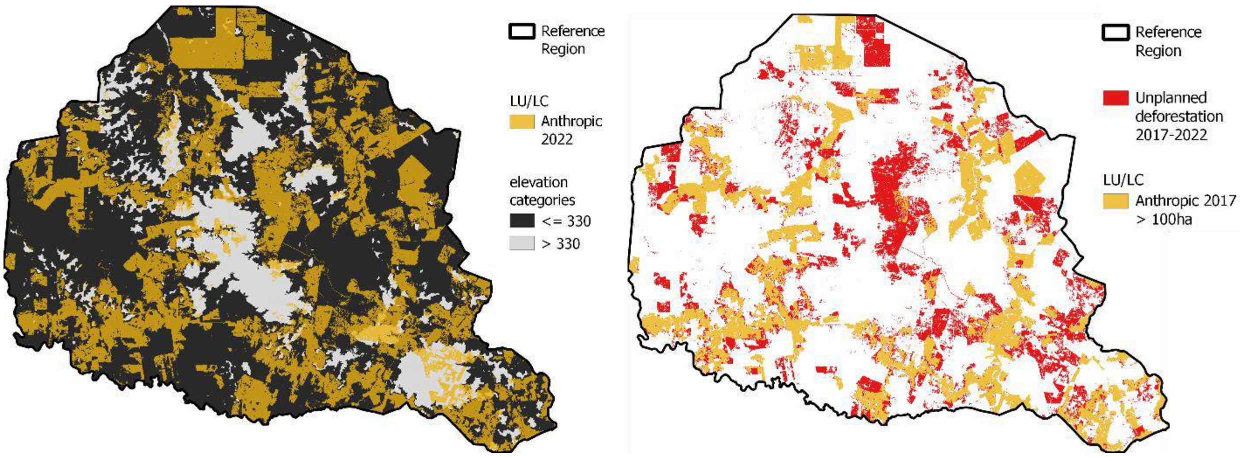


Figure 3.27. Criteria used for defining the risk zones (maps).

Next, the remaining areas of the RR are subdivided into high and medium-risk zones using a "distance to anthropic areas" criterium. As mentioned earlier, it is well known that future deforestation is more likely to occur close to already deforested areas (as evidenced, in our case, by the right map in Figure 3.27). This is entirely consistent with the most harmful deforestation dynamics taking place in the region: large-scale property owners who, in collaboration with land-grabbers, expand their activities by acquiring invaded land close to their properties. Indeed, by examining the proximity of deforestation to past anthropic areas using data from the 2017-2022 period (considering patches of pasture larger than 100 ha) we find that 46.13% of the 5-year accumulated deforestation occurred within 1 km of anthropic areas (see the right histogram of Figure 3.26). Thus, we define the "high-risk zone" – or area of optimal suitability for conversion – as the low-elevation zone within 1 km of anthropic areas larger than 100 ha. This also automatically defines the "medium risk zone" or area of average suitability for conversion.

The above definitions are described in Table 3.20 along with the total area of each risk zone. The three zones are visually displayed in the map of Figure 3.28.

Table 3.20. Description of the risk zones used in conjunction with the "Time function" approach.

ID	Name	Alias	Area (ha)	Description
RZ1	Area of "optimal" forest land suitable for conversion to non-forest land within the RR.	High-risk zone	120,632.31 ($A_{optimal}$)	Forest areas at low elevation (< 330 m) and within 1 km of deforested land patches larger than 100 ha.
RZ2	Area of "average" forest land suitable for conversion to non-forest land within the RR.	Medium risk zone	85,889.34 ($A_{average}$)	Forest areas at low elevation (< 330 m) distant more than 1 km from deforested land patches larger than 100 ha.
RZ3	Area of "suboptimal" forest land suitable for conversion to non-forest land within the RR.	Low-risk zone	53,179.74 ($A_{suboptimal}$)	Forest areas where the elevation is equal to or above 330 m.

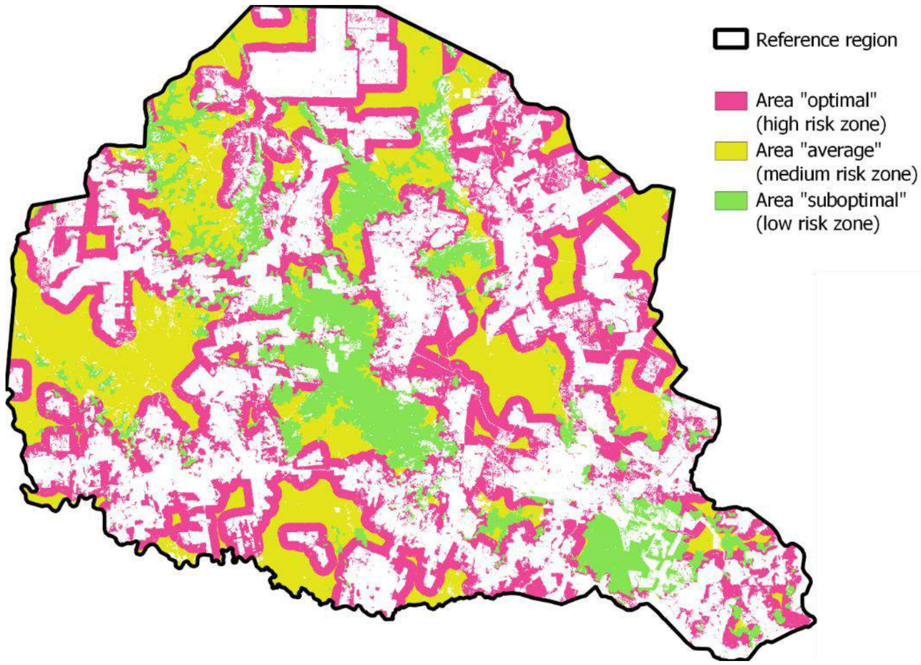


Figure 3.28. The "risk zones" defined for the "Time function" baseline approach.

Once the zones are defined, we may compute the target baseline deforestation curve. Following the methodology, the increasing trend extrapolated from the linear fit in Figure 3.25 continues until all forests located in the high-risk zone are cleared out. Deforestation then proceeds at a constant rate until the forests in the medium-risk zone are consumed. Finally, the rate starts to decrease in the way prescribed by the methodology, but it never reaches zero since between 2031 and 2032 all forest areas in the RR are predicted to have been suppressed. Table 3.21 details the amount of deforestation assigned to each risk zone for the next 10 years, and Figure 3.29 presents these results in the form of a graph.

Table 3.21. Target baseline deforestation curve for the reference region.

Project year	Interval	Reference region: deforestation per risk zones (ha)			Total baseline deforestation in the reference region (ha)	
		high risk	medium risk	low risk	annual	accumulated
1	2022 – 2023	20,874.96	0.00		20,874.96	20,874.96
2	2023 – 2024	22,756.41	0.00		22,756.41	43,631.37
3	2024 – 2025	24,637.77	0.00		24,637.77	68,269.14
4	2025 – 2026	26,519.22	0.00		26,519.22	94,788.36
5	2026 – 2027	25,843.95	2,556.63		28,400.58	123,188.94
6	2027 – 2028	0.00	28,400.58		28,400.58	151,589.52
7	2028 – 2029	0.00	28,400.58		28,400.58	179,990.10
8	2029 – 2030	0.00	26,531.55	1,869.03	28,400.58	208,390.68
9	2030 – 2031	0.00	0.00	26,980.55	26,980.55	235,371.23
10	2031 – 2032	0.00	0.00	24,330.16	24,330.16	259,701.39

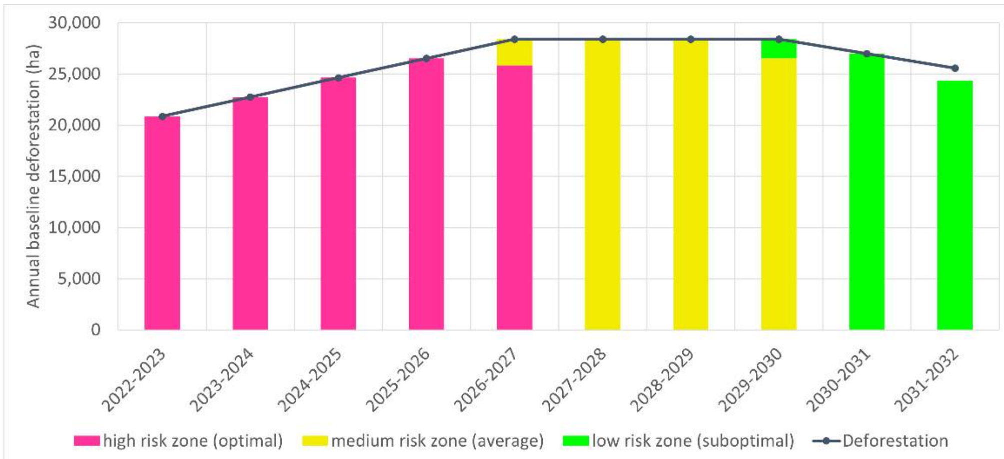


Figure 3.29. Baseline deforestation curve (target) as predicted by the "time function" approach.

Before ending this section, three important points should be made:

- The annual deforestation values of Table 3.21 are “target” values – during the location analysis, to be explained in the next section, our algorithm is not able to allocate precisely the prescribed amount of deforestation every year and a small “allocation error” is produced. This is why the deforestation values reported for the reference region in the summary below do not exactly match the values in Table 3.21.
- The risk zones were defined using model-independent criteria, meaning that the same target baseline deforestation curve applies to all candidate models to be considered for future predictions.
- Risk zones are employed only in the baseline stage of the modeling approach. They are not used during the calibration and confirmation stage (when the accuracy of candidate models is verified).

Projection of the annual areas of baseline deforestation in the project area and leakage belt

The amount of future deforestation predicted to occur within the project area and the leakage belt is computed after location analysis is performed, using standard zonal statistics tools and the shape files of the PA and LK. The summary below anticipates the results obtained from the selected baseline model (Model A) for the 10 years between 2022 and 2032.

Summary of results

Table 3.22. Annual areas of baseline deforestation in the reference region according to the selected baseline model.

Project year *t*	Interval	Annual deforestation (ha) $ABSLRR_t$	Accumulated deforestation (ha) *ABSLRR*
1	2022 – 2023	20,874.96	20,874.96
2	2023 – 2024	22,756.41	43,631.37

Project year *t*	Interval	Annual deforestation (ha) *ABSLRRt*	Accumulated deforestation (ha) *ABSLRR*
3	2024 – 2025	24,637.77	68,269.14
4	2025 – 2026	26,519.22	94,788.36
5	2026 – 2027	28,400.58	123,188.94
6	2027 – 2028	28,400.58	151,589.52
7	2028 – 2029	28,400.58	179,990.10
8	2029 – 2030	28,400.58	208,390.68
9	2030 – 2031	26,980.55	235,371.23
10	2031 – 2032	24,330.16	259,701.39

Table 3.23. Annual areas of baseline deforestation in the project area region according to the selected baseline model.

Project year *t*	Interval	Annual deforestation (ha) *ABSLPAt*	Accumulated deforestation (ha) *ABSLPA*
1	2022 – 2023	95.13	95.13
2	2023 – 2024	1,449.54	1,544.67
3	2024 – 2025	1,018.26	2,562.93
4	2025 – 2026	652.14	3,215.07
5	2026 – 2027	1,244.07	4,459.14
6	2027 – 2028	1,707.93	6,167.07
7	2028 – 2029	777.60	6,944.67
8	2029 – 2030	2,346.93	9,291.60
9	2030 – 2031	585.90	9,877.50
10	2031 – 2032	758.52	10,636.02

Table 3.24. Annual areas of baseline deforestation in the leakage belt region according to the selected baseline model.

Project year *t*	Interval	Annual deforestation (ha) *ABSLLKt*	Accumulated deforestation (ha) *ABSLLK*
1	2022 – 2023	427.14	427.14
2	2023 – 2024	664.02	1,091.16
3	2024 – 2025	779.40	1,870.56
4	2025 – 2026	1,727.19	3,597.75
5	2026 – 2027	1,922.94	5,520.69
6	2027 – 2028	557.28	6,077.97

Project year *t*	Interval	Annual deforestation (ha) *ABSLLK*$_t$	Accumulated deforestation (ha) *ABSLLK*
7	2028 – 2029	964.98	7,042.95
8	2029 – 2030	1,151.19	8,194.14
9	2030 – 2031	445.86	8,640.00
10	2031 – 2032	1,199.88	9,839.88

Projection of the location of future deforestation

In this section we employ statistical methods to predict the most probable locations of future deforestation in the RR on a yearly basis, using the annual baseline deforestation curve previously calculated. The fundamental idea is that deforestation will occur first in areas of greater risk. In evaluating the risk, we shall consider different candidate models, each being defined by a set of predictive variables represented by factor maps. Thus, the first task is to identify and prepare the relevant factor maps.

Preparation of factor maps

The variables controlling the risk of deforestation may be of several types, such as landscape, land jurisdiction, accessibility, and, of course, anthropogenic. The variables most relevant for our analysis are those related to the deforestation drivers identified in Section 3.4.2. The corresponding factor maps are listed in the tables below, with the following distinctions:

The factor maps that will be used in the construction of candidate baseline models are listed in Table 3.25 which also provides additional information about each variable. Among these, the only variable that changes with time is "distance to recent deforestation", and it must be updated when constructing calibration/confirmation risk maps and baseline risk maps. We do not consider the possibility of future changes in the region's road infrastructure.

Meanwhile, Table 3.26 lists the factor maps that have been already used in the definition of risk zones: elevation and distance to anthropic areas – in this sense these variables have already been accounted for in the baseline description; they are listed here for completeness.

Lastly, Table 3.27 lists auxiliary shape files (assets) used to compute some of the factor maps.

The tools used to build the factor maps were the Google Earth Engine (GEE) platform (GEE, 2022), the georeferencing program QGIS, and the Rasterio and GDAL libraries. The creation of factor maps follows the "empirical approach".

The factor maps are shown next in a sequence of figures – Figure 3.30, Figure 3.31, Figure 3.32, Figure 3.33 (the maps of "Accumulated deforestation (5 years)" are displayed in Figure 3.17).

Table 3.25. Factor maps employed in the location analysis.

Name	Accumulated deforestation (5 years)
IDs	FM1a, FM1b

Files	RR1_defor_accm_2012_2017.tif (FM1a) RR1_defor_accm_2017_2022.tif (FM1b)
Source	Computed with the help of the Rasterio Python library.
Variable depicted	Unplanned deforestation (or Forest ⟶ Anthropic transitions) in the corresponding time intervals.
Categories	1 – Forest 2 – Anthropic 3 – Water 4 – Secondary Forest 5 - Other 6 – Unplanned Deforestation (Numerical type: “uint8”).
Auxiliary maps	RR1_fcm_2012.tif RR1_fcm_2017.tif RR1_fcm_2022.tif
Procedures and comments	The transition maps are constructed with Rasterio by comparing initial and final coverage maps and classifying pixels that change from Forest to Anthropic as “Unplanned deforestation”. These maps are used as “Final Landscape Maps” when producing risk maps with DinamicaEGO.
Name	**Slope**
ID	FM2
File	RR1_slope.tif
Source	Calculated.
Variable depicted	Terrain slope (static variable). Unit: degrees.
Categories	Continuous variable represented with the numerical type “int 16”.
Auxiliary maps	RR1_elevation.tif (FM2)
Procedures and comments	Computed from the elevation map using a GEE built-in function.
Name	**Distance to water**
ID	FM3
File	RR1_dist_water.tif
Source	Calculated.
Variable depicted	Distance to water (static variable). Unit: meters.
Categories	Continuous variable represented with the numerical type “uint 32”.
Auxiliary maps	RIOS_DUPLOS.shp (A1)
Procedures and comments	The distance map was computed with QGIS’s built-in functions.
Name	**Distance to roads**
ID	FM4
File	RR1_dist_roads.tif

Source	Calculated.
Variable depicted	Distance to mapped roads (static variable). Unit: meters.
Categories	Continuous variable represented with the numerical type "uint 32".
Auxiliary maps	RR1_roads.shp (A2)
Procedures and comments	The distance map was then computed with QGIS's built-in functions.
Name	**Distance to recent deforestation (3 years)**
ID	FM5a, FM5b
File	RR1_dist_defor_accm_sieved_66_2014_2017.tif (FM7a) RR1_dist_defor_accm_sieved_66_2019_2022.tif (FM7b)
Source	Calculated.
Variable depicted	Distance to areas deforested during a 3-year time interval (mutable variable). Unit: meters.
Categories	Continuous variable represented with the numerical type "uint 32".
Auxiliary maps	RR1_fcm_2014.tif RR1_fcm_2017.tif RR1_fcm_2019.tif RR1_fcm_2022.tif
Procedures and comments	First, transition maps are constructed by comparing initial and final coverage maps in the corresponding dates and classifying pixels that change from Forest to Anthropic as "unplanned deforestation". The transition maps are then sieved so that only patches of deforested areas larger than 66 pixels (5.94 ha) are left. The sieving is necessary to avoid noise in the final factor maps. The procedure considers 8-connectedness and excludes the forest class from the computation (so that forest pixels are unaffected). Finally, the distance maps are produced using QGIS's built-in functions.

Table 3.26. Factor maps used for defining of risk zones.

Name	Elevation
ID	FM2
File	RR1_elevation.tif
Source	NASA Shuttle Radar Topography Mission (NASA, 2013)
Variable depicted	Terrain elevation (static variable – used for defining and validating the baseline risk zones). Unit: meters.
Categories	Continuous variable represented with the numerical type "int 16".
Auxiliary maps	-
Procedures and comments	Available through the GEE tool database. The elevation map is employed in the definition of baseline risk zones.
Name	**Distance to anthropic areas**
IDs	FM7a, FM7b

Files	RR1_dist_fcm_anthropic_gt100ha_2017.tif (FM6a) RR1_dist_fcm_anthropic_gt100ha_2022.tif (FM6b)
Source	Calculated.
Variable depicted	Distance to anthropic areas larger than 100 ha (mutable variable – used for defining and validating the baseline risk zones). Unit: meters.
Categories	Continuous variable represented with the numerical type "uint 32".
Auxiliary maps	RR1_fcm_2017.tif RR1_fcm_2022.tif
Procedures and comments	The "Anthropic" class in the coverage map was first sieved so that only patches larger than 1100 pixels (99 ha) remained. The sieving, necessary to avoid noise in the final factor map, considers 8-connectedness and excludes the forest class from the computation (forest pixels are unaffected). A distance to anthropic areas map is then produced. Operations are made with QGIS. These maps are employed in the definition of baseline risk zones.

Table 3.27. Assets used to compute some of the factor maps.

File	RIOS_DUPLOS.shp
Source	FBDS database (https://www.fbds.org.br/).
File	RR1_roads.shp
Source	IBGE database (https://www.ibge.gov.br/geociencias/downloads-geociencias.html)

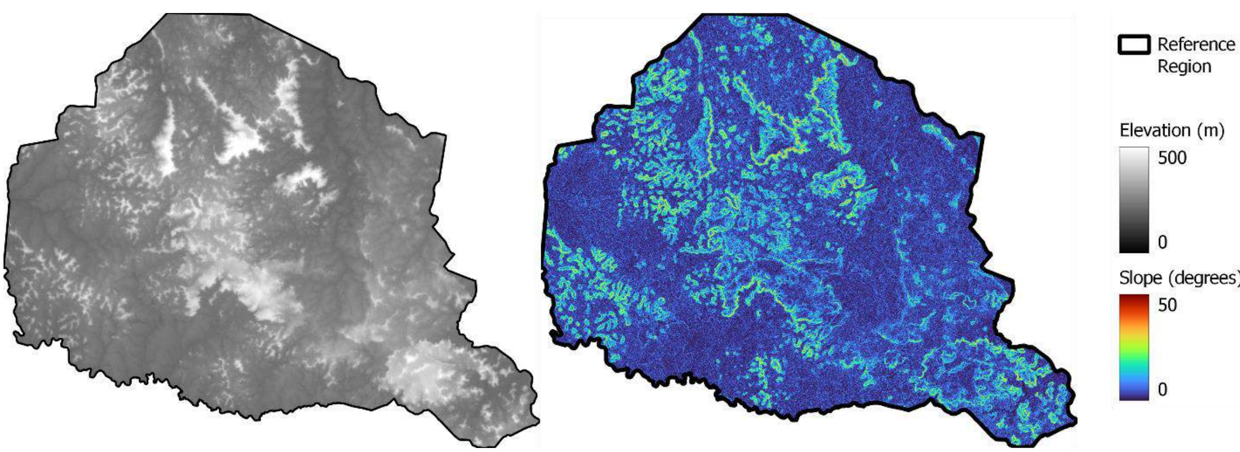


Figure 3.30. Factor maps: elevation and slope.

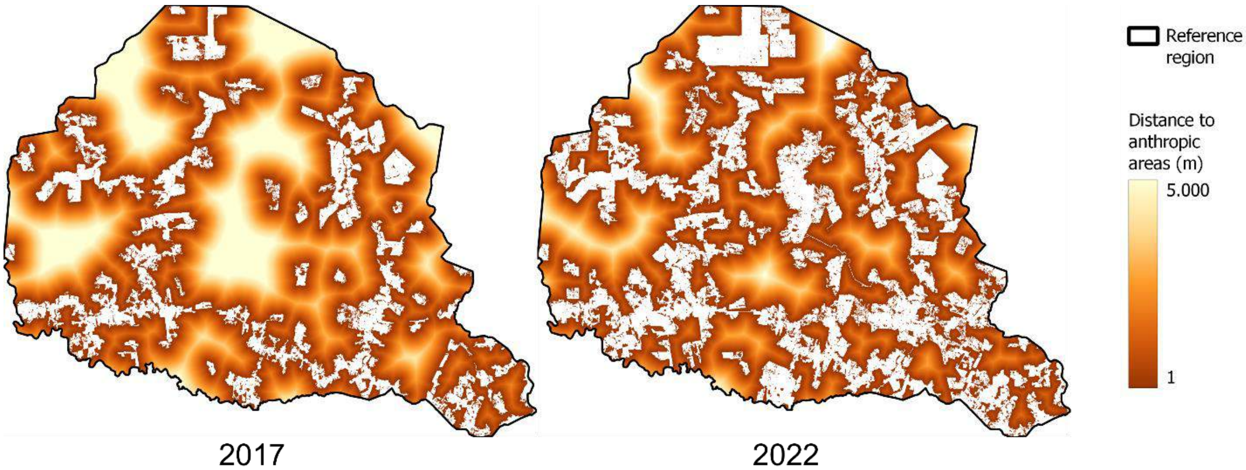


Figure 3.31. Factor map: distance to anthropic areas (connected patches larger than 100 ha).

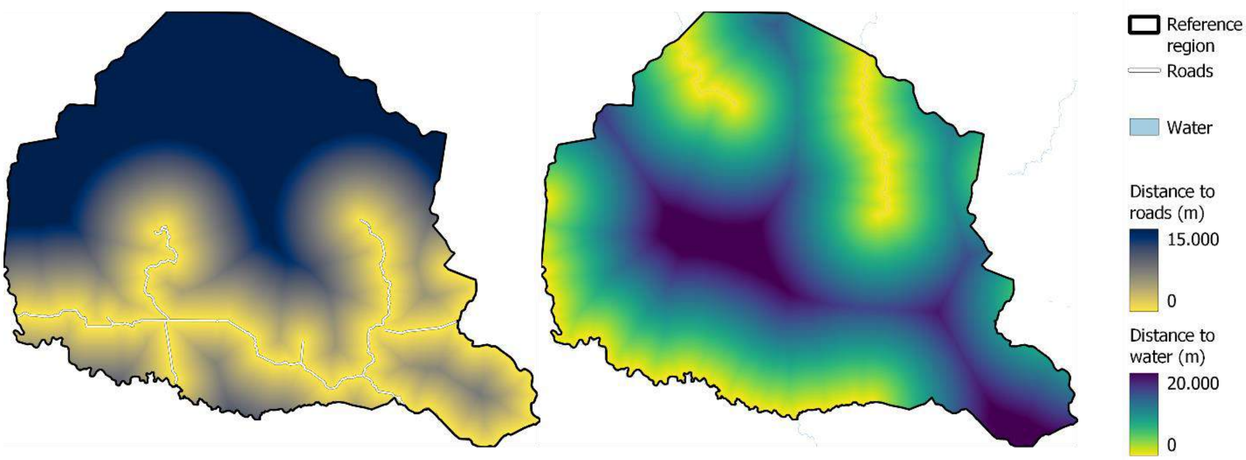


Figure 3.32. Factor maps: distance to roads and distance to water.

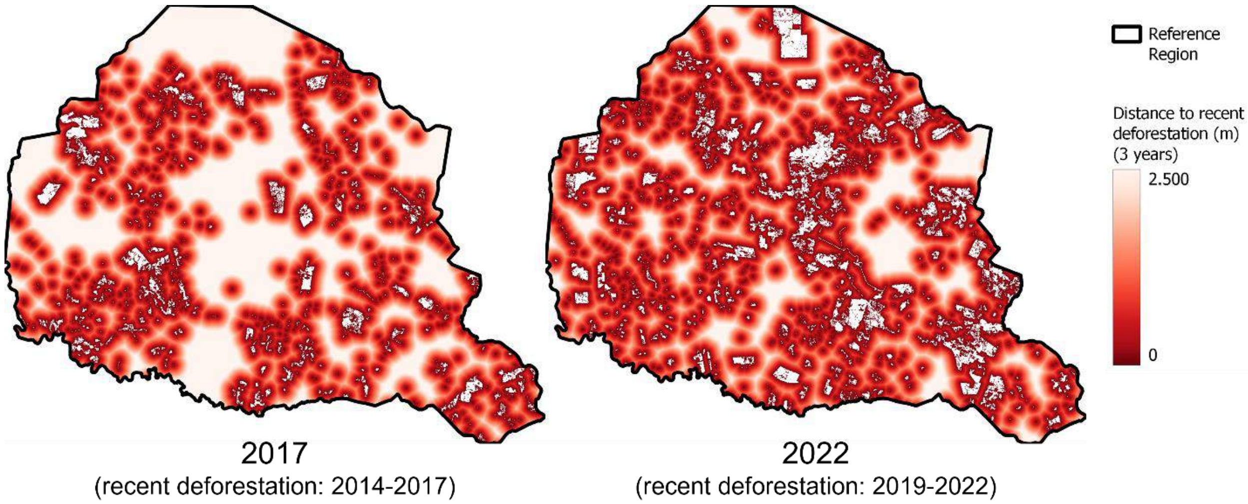


Figure 3.33. Factor maps: distance to recent deforestation (distance to 5-years accumulated deforestation patches larger than 5,94 ha). This is a mutable variable in our models.

Preparation of deforestation risk maps

Risk maps are a spatial representation of the probability of occurrence of deforestation transitions (in our case, the "Forest → Anthropic" transition). Each class, or category of a given variable contributes a "weight of evidence" to that probability, which is calculated by comparing initial and final landscape maps and resolving the distribution of deforestation transitions according to the classes of the variable. The risk map for a candidate model is constructed pixel-by-pixel by combining the weights of all the model's variables. This statistical approach to generating risk maps is sometime referred to in the literature as the "weights of evidence method" (WOE). (Bonham-Carter & Bonham-Carter, 1994).

We employ the software DinamicaEGO (Soares-Filho, Cerqueira, & Pennachin, 2002) to calculate the weights of evidence for each variable and generate the risk maps for different candidate models. The program also performs the categorization of continuous factor maps, which is required by the WOE method. DinamicaEGO was used in the preparation of risk maps. The value associated with each forest pixel in the risk map represents the probability of loss for that pixel. The probability is modeled according to a logistic function, a widely used model for this type of system, where one seeks to predict a binary outcome (permanence or loss). In this aspect, DinamicaEGO is very similar to logistic classifiers (in machine learning terminology). There are two main differences, however, in relation to those: (i) there is no background coefficent in the DinamicaEGO model, so the null hypothesis is a 50/50 probability for either permanence or loss; (ii) the coefficients of the model (the "weights of evidence") which control whether deforestation is less or more likely at a given location, are found by means of Bayesian techniques rather than sampling and fitting. All these are well-established statistical techniques, therefore justifying the use of DinamicaEGO in the construction of our risk maps.

The candidate models correspond to different possible selections of explanatory variables – the models considered in our analysis will be discussed in the next section. Here we shall explain in general terms the two stages of the location analysis: the calibration and confirmation stage, whose purpose is to evaluate the accuracy of the model, and the baseline stage, whose purpose is to allocate future deforestation. Each stage requires a separate risk map. The allocation algorithm (used in both stages) is implemented in a Python script, by adapting some of the functions available in the open-source ForestAtRisk package (Vieilledent, 2021).

Calibration and confirmation stage

Calibration is the assignment of weights of evidence coefficients to each variable of a model, based on initial and final landscape maps for a given region. Confirmation is the evaluation of the model's accuracy indexes related to predicted vs. observed transitions for a given time window.

The methodology allows two approaches for this stage which may be termed the "temporal domains" approach and the "spatial domains" approach. In a nutshell, in the "temporal domains" approach calibration and confirmation are performed on separate time windows, but over the same geographical region; in the "spatial domains" approach calibration and confirmation are performed on the same time window but over separate regions.

The methodology recommends following the "spatial domains" approach if "only one historical sub-period is representative of what is likely to happen in the future". In the present case, since deforestation has been steadily increasing during the historical period (Figure 3.24), the older rates of the first half-period (2012-2017) are outdated whereas the rates of the second half-period (2017-2022) are more representative of what will happen in the future. Therefore, we adopt the "spatial domains" approach for calibration and confirmation.

The steps for model calibration and confirmation under this approach are schematically presented in Figure 3.34. The time window is from 2017 to 2022 (most recent half of the historical period). The reference region must first be split into separate spatial domains, the "calibration domain" and the "confirmation domain" (the splitting employed in our models is presented in the next section). Then, the procedures are the following: Step 1: Factor maps and initial and final landscape maps are prepared for the calibration domain. Step 2: The calculation of the weights for each variable is performed over the calibration domain. Step 3: Factor maps and the initial landscape map are prepared for the confirmation domain and weights computed in the calibration domain are selected for the candidate model. Step 4: A risk map is generated over the confirmation domain, combining the weights of the current model's variables according to their distribution in the confirmation domain.

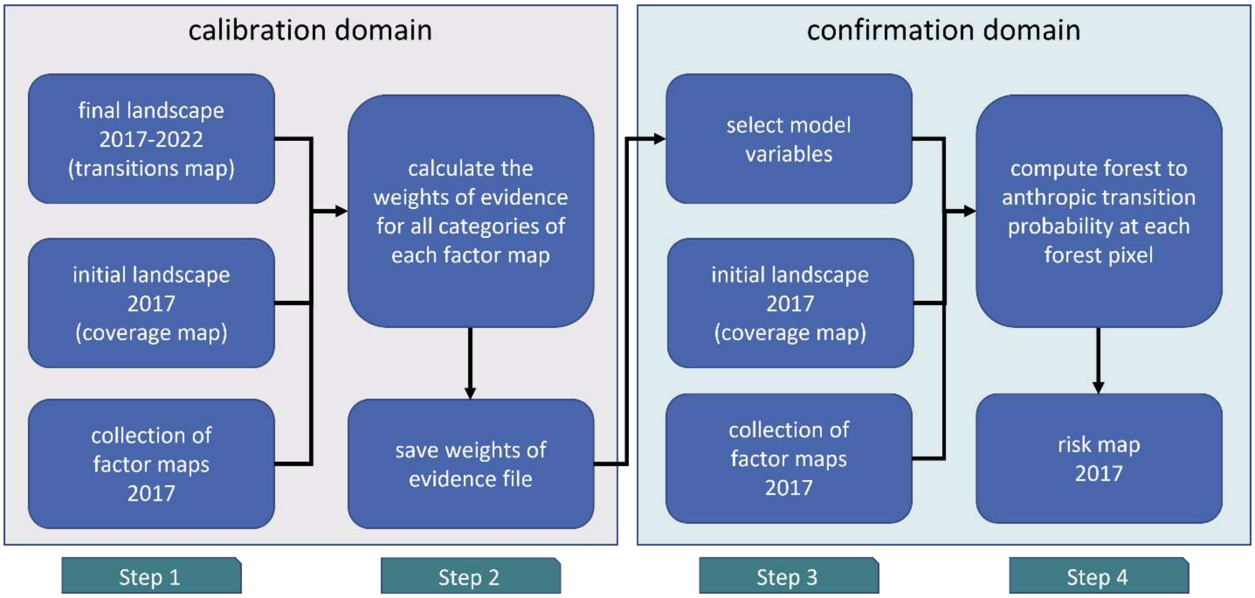


Figure 3.34. Flow chart explaining the construction of risk maps for model accuracy assessment using separate spatial domains for model calibration and confirmation (in this case performed over the same time period).

The risk map is then used to allocate a pre-specified amount of deforestation over the confirmation domain, in the period between 2017 and 2022; this generates the predicted deforestation map in the confirmation domain. The predicted map is then compared to the observed map and a confusion matrix is generated from which accuracy indexes can be computed. This completes the calibration and confirmation stage.

Baseline

The steps for constructing baseline risk maps are very similar, as demonstrated in Figure 3.35. The calibration in Steps 1 and 2 is carried out in the same manner as before, with the same calibration spatial domain that was used for assessing the model's accuracy (meaning that the previously calibrated weights persist). The next two steps are slightly different: The input maps in Step 3' are now the factor maps and initial landscape map for the complete reference region in 2022. Likewise, in Step 4' the output risk map now refers to the whole RR and represents the risk in 2022. Once the 2022 risk map is available deforestation can be allocated during the baseline years. Importantly, both the risk zone hierarchy and the risk map's probability hierarchy must be obeyed during the allocation, with the former having precedence over the latter.

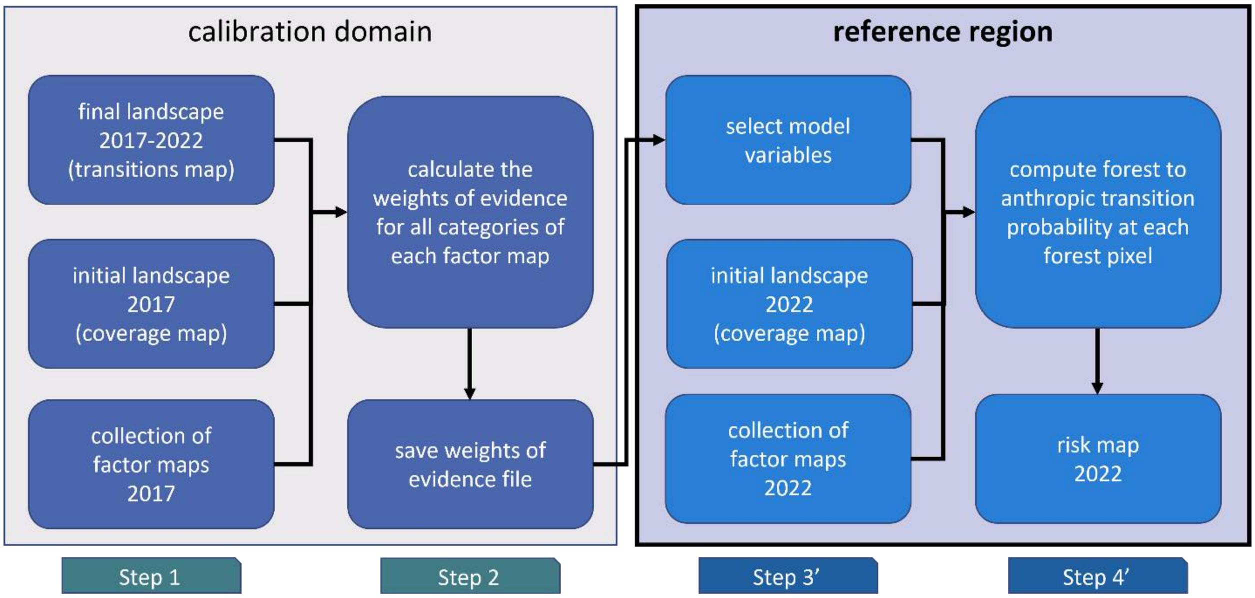


Figure 3.35. Flow chart explaining the construction of risk maps for the reference region at the start of the baseline period.

Selection of the most accurate deforestation risk map

The most accurate baseline risk map will be the one whose corresponding model performs best in terms of accuracy metrics computed during the confirmation state. We shall adopt the Figure of Merit (FOM) index as a standard metric. The FOM can be directly evaluated from the elements of the confusion matrix for predicted vs. observed maps produced in the confirmation stage using the formula:

$$FOM = \frac{CORRECT}{CORRECT + Err_A + Err_B} \quad \text{Equation 1}$$

Where:

$CORRECT$	Area correct due to observed change predicted as change; ha
Err_A	Area of error due to observed change predicted as persistence; ha
Err_B	Area of error due to observed persistence predicted as change; ha

Several models must be tested, each using a different selection of factor maps. However, there is a limited number of sensible models.[97] The three models that can be constructed by combining at least

[97] Other typically employed variables, such as "indigenous lands", or "lands under special jurisprudence", are too far away to be considered. Also, recall that "distance to anthropic areas" and "elevation" were used in the definition of risk zones. Additionally, it must be noted that one of the assumptions of the WOE method is that the set of variables used in the model are spatially uncorrelated (often a tolerance on the correlation value – as computed by some of the standard correlation metrics – is imposed). We find that "distance to anthropic areas" and "distance to recent deforestation" have a strong spatial

three variables are shown in Table 3.28 (“distance to recent deforestation” and “distance to roads” are too important to be left out and are thus considered mandatory in all models). The factor map ID corresponding to each variable is also listed.

Table 3.28. The candidate baseline models.

Variable type	Model A	Model B	Model C
Landscape	slope (FM2)	slope (FM2)	
Accessibility	distance to roads (FM4)	distance to roads (FM4)	distance to roads (FM4)
Resource	distance to water (FM3)		distance to water (FM3)
Anthropogenic	distance to recent deforestation (3 years) (FM5b)	distance to recent deforestation (3 years) (FM5b)	distance to recent deforestation (3 years) (FM5b)

These models are calibrated and tested according to the “spatial domains” approach described in the previous section. The calibration and confirmation domains were defined by tiling the reference region with 1 km wide (side-to-side) hexagons and randomly assigning half of them to each domain (Figure 3.36). This results in a nearly uniform distribution of tiles belonging to each domain across the reference region so that the evaluation of weight coefficients can be as free as possible from spatial sampling bias.

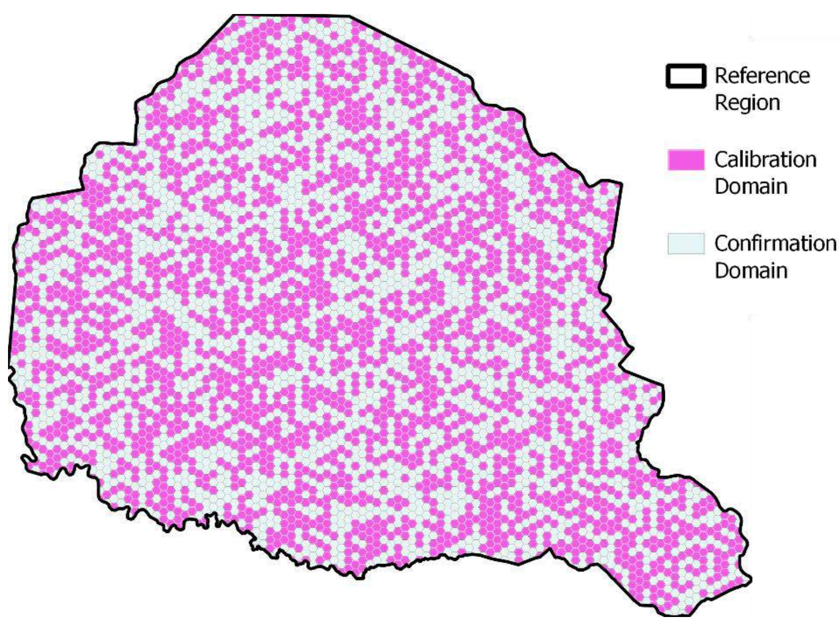


Figure 3.36. Spatial domains used for model calibration and confirmation.

correlation, which thus prevents these variables to be combined in the same model. Similarly, “elevation” has a non-negligible spatial correlation with “slope”.

According to the methodology, the FOM threshold value is determined by the ratio between the deforestation observed in the calibration domain and the total area of the calibration domain (both of which can be found by simple pixel-counting tools): $FOM_{threshold}$ = (29,328.75 ha) / (213,391.71 ha). This returns a value of 0.137. Models must have a FOM larger than the threshold to qualify as acceptable.

Once the risk map for the confirmation domain has been produced following the steps of Figure 3.34 we proceed to allocate the target deforestation for the 2017-2022 period, which equals the accumulated deforestation observed within the confirmation domain in that period: a total of **29,814.12 ha.**

The allocation is performed following a "higher-risk first" protocol. After comparing predicted vs. observed transition maps, a confusion matrix is generated and the FOM is computed. It must be noted that the allocation algorithm is not always able to allocate the precise amount of target deforestation and the process gives rise to an allocation error.[98] This error propagates to the accuracy indexes. Under simple assumptions, the resulting uncertainty in the value of the FOM can be estimated. Similar reasoning allows us to estimate the allocation error within sub-regions of the RR, such as the project area, for example, in the case of baseline predictions (the assumption here is that the error per unit area is uniform across the RR). This turns out to be relevant to our analysis since the accuracy indexes of the models are very close and we need auxiliary criteria to decide which one is the best model – more details on the uncertainty estimation be found in the modeling annex.[99]

The accuracy results for the three candidate models are presented in Table 3.29.

Table 3.29. Candidate baseline models: results.

Variable type	Model A	Model B	Model C
Landscape	slope	slope	
Accessibility	distance to roads	distance to roads	distance to roads
Resource	distance to water		distance to water
Anthropogenic	distance to recent deforestation (3 years)	distance to recent deforestation (3 years)	distance to recent deforestation (3 years)
FOM	0.263 ± 0.045	0.248 ± 0.044	0.263 ± 0.025

[98] The risk maps are capable of distinguishing 65355 risk classes. The number of populated risk classes, however, is much lower, due to the relatively small number of factor maps in our models. Hence, many pixels share the same risk values, and sometimes there will be no way of deciding which of those should be marked as deforested and which should not. In these cases, the algorithm opts for the choice that minimizes the error, either by marking all or none of the same-risk pixels, leading to an overestimation or sub estimation of the target deforestation value at the corresponding period.

[99] Annex: 221020_ TDX-BASELINE_MODELING.zip

Predicted 3-year deforestation at PA (ha)	2,562.33 ha	2,766.24 ha	2,590.74
Estimated 3-year allocation error at PA (ha)	-10.22 ha	+342.10 ha	-775.40 ha

The first thing to note is that for all three models the FOM is above the threshold value of 0.137, so they are all acceptable. The table presents, besides the FOM metric, two other auxiliary results: the predicted deforestation in the project area within a 3-year time frame, and the accumulated allocation error estimated for that prediction.[100]

Based on these metrics, **Model A** is selected as the best model.

The reasoning is that, despite the similarity of the candidate models with respect to FOM, especially considering the estimated uncertainties, Model A is the one with the smallest 3-year accumulated allocation error and the one with the most conservative estimate for baseline deforestations occurring in the PA within a 3-year time frame.

Figure 3.37 provides a visual display of the accuracy assessment results for Model A; results from the other models are included in an annex.[101]

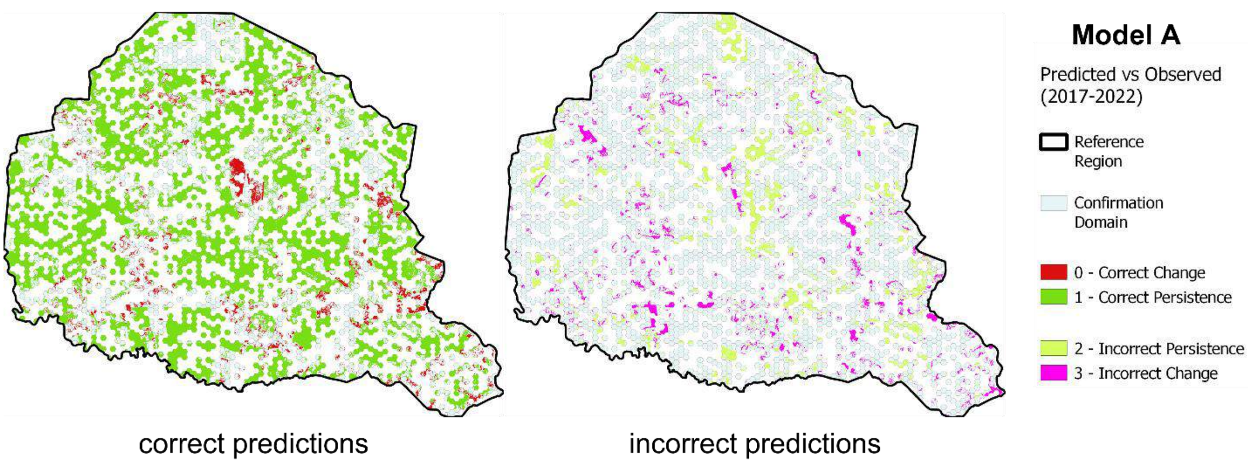


Figure 3.37. Accuracy assessment of Model A: correct and incorrect predictions for the most recent half of the historical period, 2017-2022.

Mapping of the locations of future deforestation

Once the baseline model has been elected, we proceed to construct its baseline risk map so that future deforestation can be predicted. The baseline risk map generated by Model A is shown in Figure 3.38. The probability of deforestation transitions is represented in unnormalized form using risk classes numbered

[100] Note that these additional metrics require the baseline allocation to be performed for the three models. Also, the 3-year interval is arbitrary, but we find it reasonable to judge the models from estimates taken halfway through the baseline period.

[101] Annex: 221020_ TDX-BASELINE_MODELING.zip

from 1 to 65355. The risk is evaluated only over the "Forest" class, the more intense the red colors the higher the deforestation risk. For reference, Figure 3.39 shows the risk evaluated at forest areas within the TdX-I1 project properties.

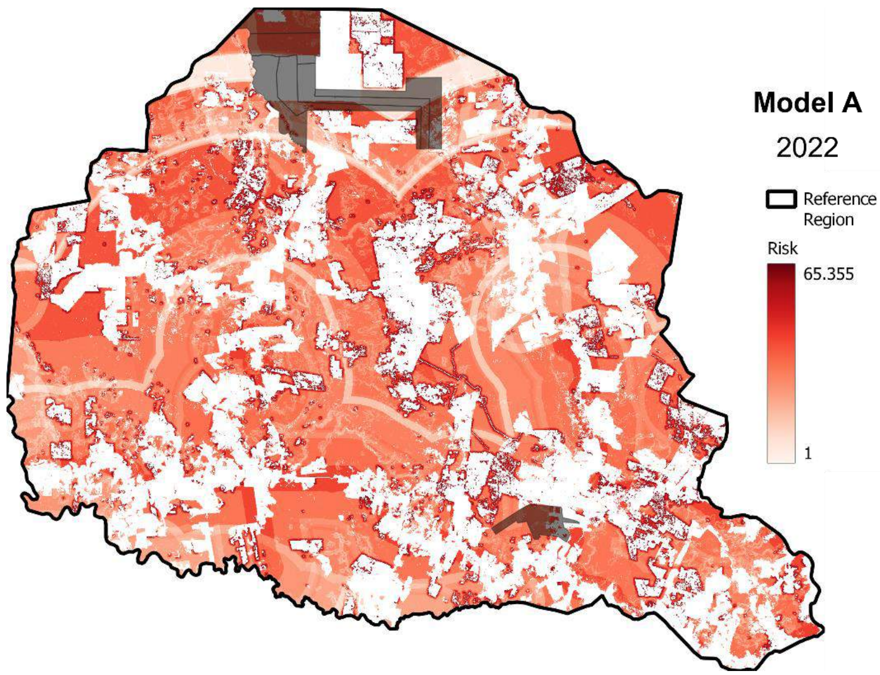


Figure 3.38. Baseline risk map for Model A.

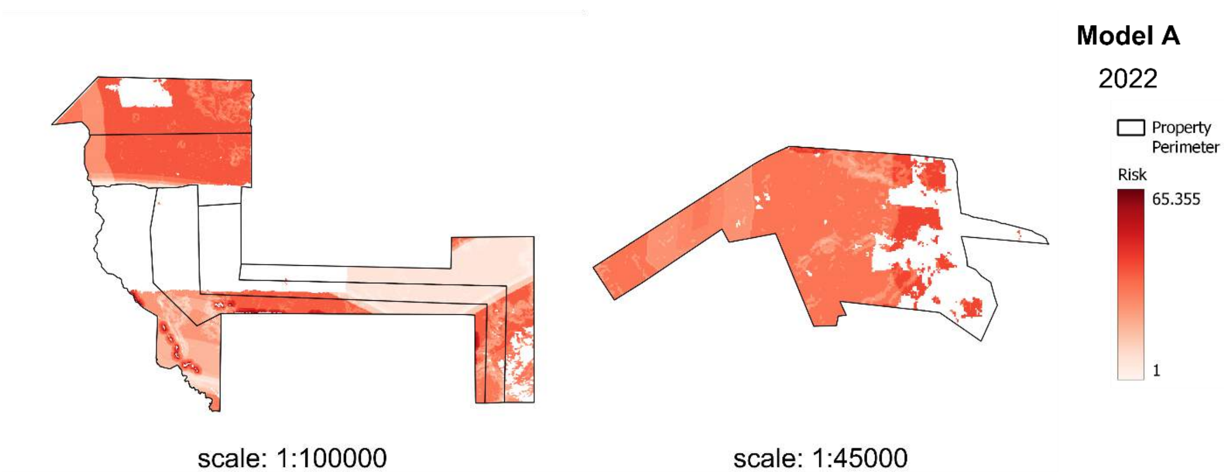


Figure 3.39. Baseline risk map for Model A at the different properties of the project.

The same allocation algorithm used during the calibration and confirmation stage is now employed to find the locations of future deforestation. The new aspect involved in the baseline prediction is that the hierarchy of the risk zones defined by the criteria listed in Table 3.20 must be respected, with the target amount of deforestation allocated at each risk zone at each year being defined by the values in Table

3.21 (plotted in Figure 3.29). Within risk zones, the allocation is made on a “higher-risk-first” protocol, as before.

The predicted annual deforestation for the 6 years of the baseline period is shown in Figure 3.40. The deforestation allocated within the reference region, project area, and leakage belt for the 10 years following the start date was previously given in Table 3.22, Table 3.23, and Table 3.24, respectively.

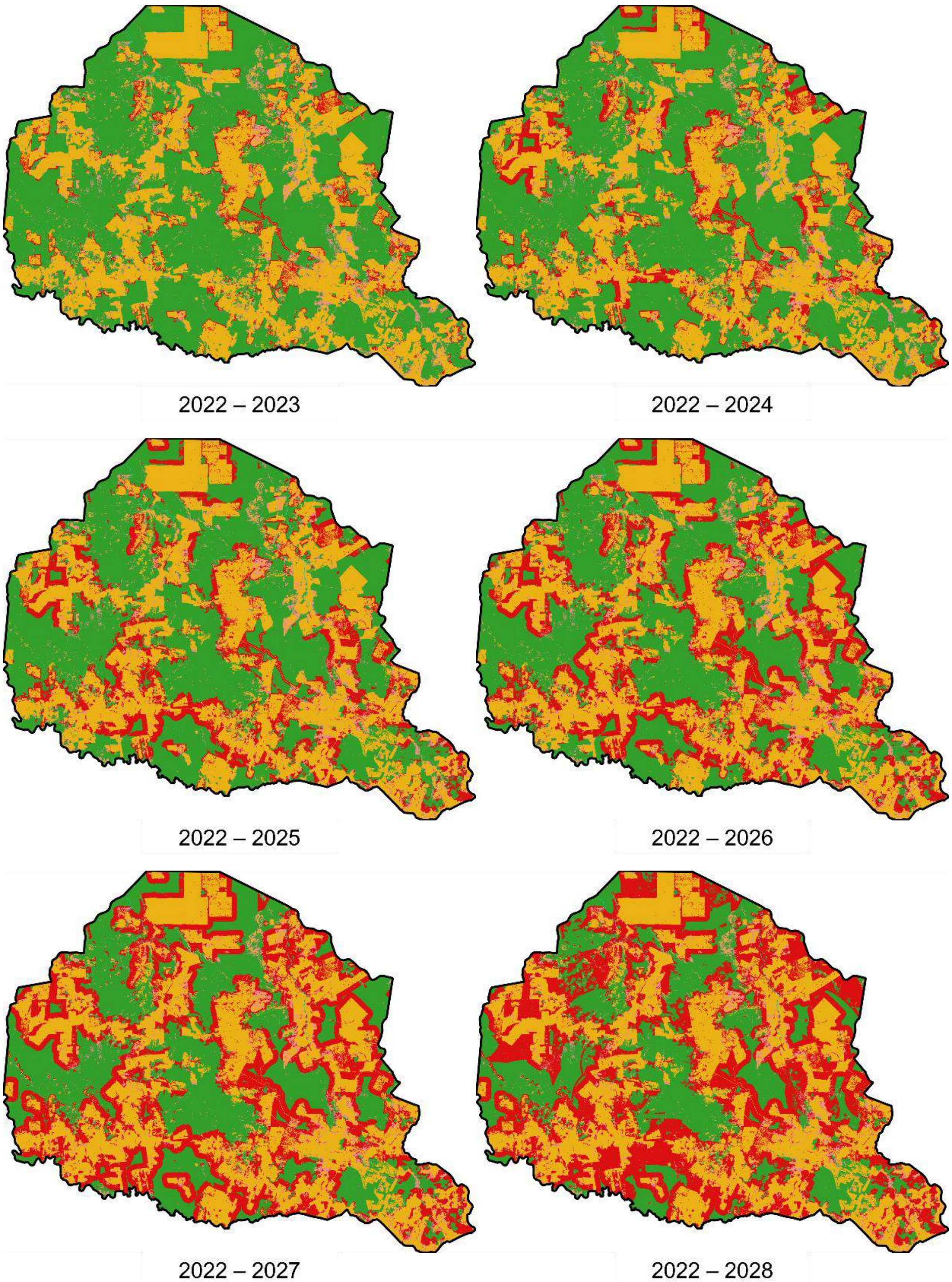


Figure 3.40. Predicted baseline deforestation (6 years).

3.5 Additionality

The project additionally assessment was carried out according to the most recent version of the VCS tool "VT0001 – Tool for the Demonstration and Assessment of Additionally in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities, version 3.0, 1 February 2012, Sectorial Scope 14.

Both applicability conditions from the tool are met because the project AFOLU activity the same or similar to the proposed project activity on the land within the proposed project boundary performed with or without being registered as the VCS AFOLU project does not lead to violation of any applicable law even if the law is not enforced, and the most plausible baseline scenario is justified in section 3, item 3.4 Baseline Scenario, under the VM0015 methodology application.

3.5.1 Step 1. Identification of alternative land use scenarios to the proposed VCS AFOLU project activity

Sub-step 1a. Identify credible alternative land use scenarios to the proposed VCS AFOLU project activity

All realistic and credible land use scenarios were identified considering relevant national and/or sectoral policies and circumstances, such as historical land uses practices and economic trends. The list of credible alternative land use scenarios that would have occurred on the land within the project boundary of the VCS AFOLU project is described below:

i. **Continuation of the pre-project land use (BAU activities occurring).**

This scenario involves the maintenance of the preserved forest area by the landowners, without any source of supplementary income. However, no REDD+ activities are implemented, nor any stakeholder engagement to prevent the drivers of deforestation to act as a source of carbon loss. Monitoring and surveillance measures, taken by the landowners, will be made to privilege primarily livestock activities, then to avoid any eventual external agents land invasion being conducted by forest clearing with fire, followed by cattle ranching (business as usual scenario). Only the surveillance already done by the landowners would be applied, but not enough to stop the deforestation patterns identified in Section 3.4. BAU activities that already take place in the rest of the property – and outside of the project area - will continue to occur, and no social or biodiversity activity will be carried forward.

Then, considering the context it is expected that part of the properties will be deforested by external agents considering the ratio of the unplanned deforestation activity in the reference area, and because the related environmental legislation is systematically not enforced. The first actor in this process is the squatter, who does the practice of "grilagem", as it is called in Portuguese. Once the squatters cleared the land cover with fire, without the benefits of logging, some cattle heads are placed in the area to start the domain process. Then, the ranchers take the livestock activities even in a rudimentary way.

Evidence shows that 40% of the APA Triunfo do Xingu have already been converted to other land use different from the native vegetation, being livestock the most common use (Xingumais, 2021). It was also the environmental protection area most pressured by unplanned deforestation in the first quarter of 2022 (IMAZON, 2022a). Data from Prodes (TerraBrasilis, 2022) and Justice C (2006) compiled in Figure

3.41 shows the burn areas in the reference project region in the last 20 years, followed by pasture areas occupation.

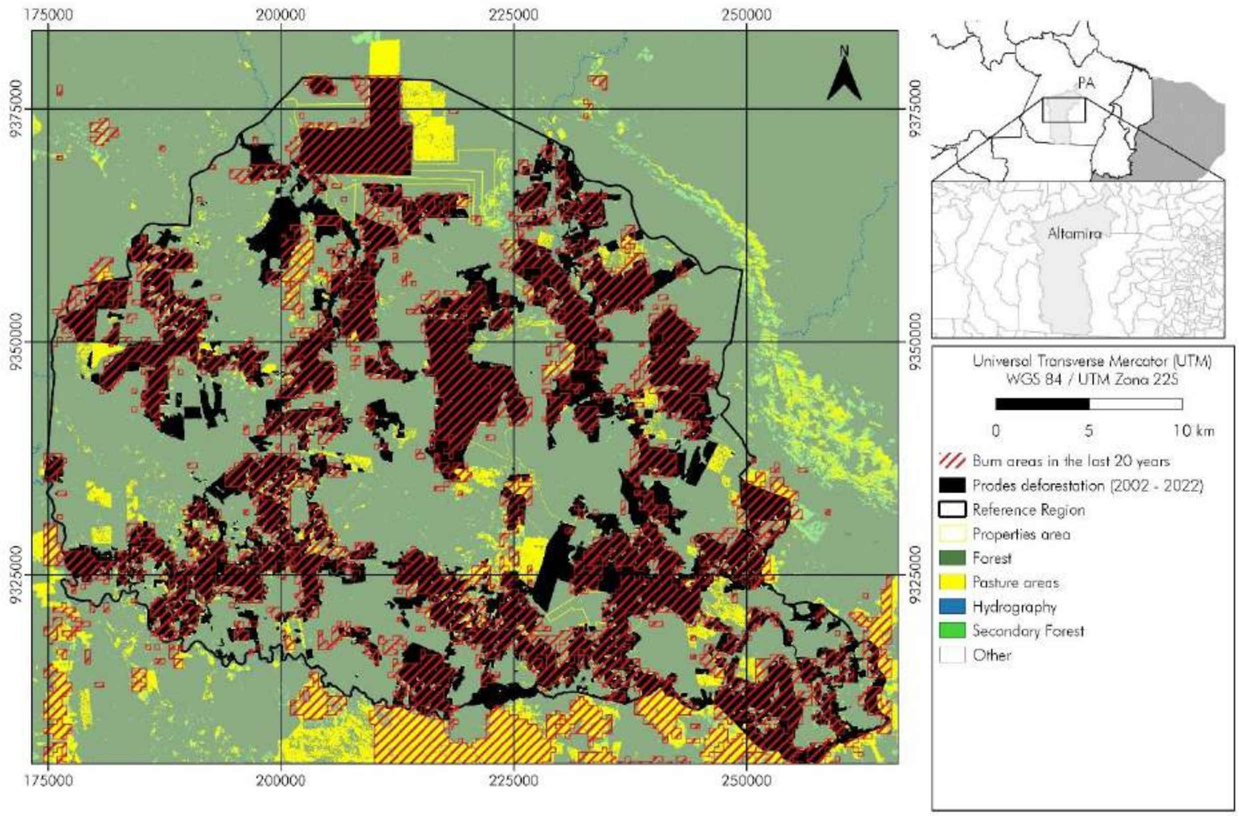


Figure 3.41. BAU Scenario in the TdX Reference region

Of the 1.68 million hectares total area of APA Triunfo do Xingu, 66% of them are inside the São Felix do Xingu municipality, adjacent to the Altamira municipality, where are located the other 34% forest area of the APA (Pará State Decree Nº 2,612/2006 (SEMA, 2006)). São Felix do Xingu is the region of Brazil with the biggest number of cattle heads, having 2.468 million of them (IBGE, 2021b). For comparison purposes: the second municipality with the second highest number of cattle heads in Brazil is the municipality of Corumbá, with 1.838 million. Although Altamira does not have the amount of São Felix do Xingu's cattle heads, it is in the tenth position of Brazil with 904,271. Cattle ranching is a usual practice in the region (Xingumais, 2021), and farms can be implemented within the limits of the Forest Code, being able to deforest up to 20% of the property for pasture.

ii. **Project activity on the land within the project boundary performed without being registered as the VCS AFOLU project.**

The scenario would be the same one as described in option (i), but in this second scenario, effective measures would happen to curb local illegal deforestation. Such measures were presented in section 1.11. Description of the Project Activity of this PD, they involve:

- Frequent patrolling and surveillance activities are taken by employees with this specific task. Monitoring checkpoints and the necessary equipment (food, water, motorcycles, mobile phones) will be provided to support with the task.
- Satellite monitoring will be done to identify fire alarms disclosed by the Mapbiomas Alert initiative. Geospatial analysis can help to anticipate fires by tracking their advances. A deforestation pattern or regions with higher risk near the properties can be identified and provide information to create a mitigation plan.

Although being an interesting scenario, it also has the important characteristic of being completely financed by the landowners, which wouldn't receive any kind of additional revenue executing those actions.

iii. Logging being conducted through Sustainable Forest management.

Logging in the State of Pará is a practice that occurs legally and illegally. This is because the related environmental legislation is systematically not enforced, and for that logging could take place through or not the approval of the sustainable forest management plan. In a study conducted by Sistema de Monitoramento da Exploração de Madeira - Simex (IMAZON, 2022b), it was detected in the State of Pará the timber farm for an area of 57,079 ha in the period (Aug/2020 – Jul/2021), being 59% of the total area legally exploited. While for the unauthorized activity, most of it was identified within registered rural properties (17.496 ha or 75% of total illegally logging) (IMAZON, 2022b).

According to the legislation on the subject, there is the possibility to execute forest management activities in the forest areas from a Legal Reserve (LR) inside an APA. In this scenario, the landowner would have to develop and approve a sustainable forest management plan under the competent environmental agency to explore his legal reserve area. Executing forest management to benefit from timber resources is an expensive activity but that would generate some revenue for the landowners. Those resources could be used to maintain the integrity of the forest area once it would start to have economic value. Actions to prevent illegal deforestation would be easier to take than such as patrolling and satellite monitoring, maybe not as strong and effective as in scenario (ii), but much better than doing nothing as in scenario (i).

Sub-step 1b. Consistency of credible land use scenarios with enforced mandatory applicable laws and regulations

Considering the three credible alternative land use scenarios from sub-step 1a, a demonstration of compliance with all mandatory applicable legal and regulatory requirements was made in the next paragraphs.

i. Continuation of the pre-project land use (BAU activities occurring).

Maintaining the activities already done before the TdX project, the landowner would continue to be in accordance with the pertinent legislation, already detailed in Section 1.14. Both Sefer and Didacio have the rights to explore 20% of their lands in the most appropriate way they decide to, according to the Brazilian Forest Code, that's what they already do and would continue to execute in this scenario. All the unplanned activities that would take place in the forest area are done by external agents, such as squatters and ranchers that invade private and public land for cattle ranching. According to the exposed before, all the legislation that prevents unplanned deforestation in the Amazon is systematically not enforced in the project reference area.

ii. Project activity on the land within the project boundary performed without being registered as the VCS AFOLU project.

In terms of compliance, in the same way as scenario (i) both landowners from the TdX-I1 comply with the legality already described in Section 1.14. Besides the economic activities done in 20% of their lands, the additional activities executed to avoid invaders do not imply compliance with any legislation that has not already been complied with.

iii. Logging being conducted through Sustainable Forest management

The Brazilian Forest Code (Law Nº 12,651, 2012 (Brasil, 2012)) allows forest management practices inside the LR area of rural property, meaning that additional revenues could be generated by the landowner. The Legal Reserve is an administrative limitation that is provided for in Law 12.651/2012, in its article 12, as below *in verbis*:

"Art. 12. Every rural property must maintain an area with native vegetation coverage, as a Legal Reserve, without prejudice to the application of the rules on Permanent Preservation Areas, observing the following minimum percentages in relation to the area of the property, except in the cases provided for in Art. 68 of this Law: (Redrafted by Law No. 12727 of 2012).

I - located in the Legal Amazon

(a) 80% (eighty percent), on the property located in a forest area" In the same norm, with the purpose of encouraging the environmental regularization of properties, chapter XIII of the Native Vegetation Protection Law provides for the Environmental Regularization Program (PRA). Through this program, it is possible for landowners with environmental liabilities related to the irregular suppression of Permanent Preservation Areas, Restricted Use and Legal Reserves, which occurred before July 22, 2008, to adapt their properties.

Adhesion to the program is by registering in the Rural Environmental Registry (CAR), as determined by § 2nd of article 59 and § 29 of the Brazilian Forest Code, below in verbis:

"Art. 59 The Union, the States and the Federal District shall implement Environmental Regularization Programs (PRAs) for rural properties and possessions, with the aim of bringing them into line with the terms of this Chapter. (...) § 2 The registration of rural properties in the CAR is a mandatory condition for joining the PRA, which will be requested by the owner or possessor of the rural property within 180 (one hundred and eighty) days, as of the summons by the competent body, subject to the provisions of § 4 of art. 29."

(...)

"Art. 29 - The Rural Environmental Registry (CAR) is created, within the scope of the National Environmental Information System (SINIMA), as a national electronic public registry, mandatory for all rural properties, with the purpose of integrating environmental information from rural properties and

possessions, making up a database for control, monitoring, environmental and economic planning and combating deforestation. (...) § 4 Owners and possessors of rural properties that register them in the CAR by December 31, 2020 will be entitled to join the Environmental Regularization Program (PRA), referred to in art. 59 of this Law." (Brasil, 2012)

Obligation that the rural properties included in the project are compliant. This is proven through a statement extracted from the National Rural Property Registration System (SICAR)[102]. Therefore, according to article 60 of the Forest Code, the Legal Reserve deficit has its punishability suspended due to adhesion to the PRA, *in verbis:*

"Art. 60 - The signing of a term of commitment to regularize the property or rural possession before the competent environmental agency, mentioned in art. 59, will suspend the punishability of the crimes foreseen in arts. 38, 39 and 48 of Law nº 9.605, of February 12, 1998, while the term is being complied with. (See ADIN Nº 4.937) (See ADC Nº 42) (See ADIN Nº 4.902)"

In this same regard, it is possible to attest to the environmental regularity of Mr. Rafael Sefer and Mr. Didácio Milhomens vis-a-vis the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA), an autarchy in charge of environmental preservation, since there are no fines or debts related to the referred owners in its database. Therefore, their compliance with the rules in force is proven by the negative certificate .

Some other important articles of the Brazilian Forest Code also states that:

"Art. 17. The Legal Reserve must be conserved with native vegetation cover by the rural property owner, owner or occupant in any capacity, individual or legal entity, public or private law.

> *§ 1 The economic exploitation of the Legal Reserve is admitted through management sustainability, previously approved by the competent body of SISNAMA, in accordance with the modalities provided for in art. 20.*

(...)

Art. 20. In the sustainable management of the forest vegetation of the Legal Reserve, practices of selective exploitation adopted in the modalities of sustainable management without purpose commercial for consumption on the property and sustainable management for forest exploitation with commercial purpose.

(...)

Art. 22. Sustainable forest management of the Legal Reserve vegetation with purpose commercial activity depends on authorization from the competent body and must comply with the following guidelines:

[102] Annex: 230518_TdX Proof of Title.zip

I – do not de-characterize the vegetation cover and do not harm the conservation of the native vegetation of the area;

II - ensure the maintenance of species diversity;

III - conduct the management of exotic species with the adoption of measures that favor the regeneration of native species." (Brasil, 2012)

Article 225, § 1st, III, of the Federal Constitution states that the government is responsible for "*defining, in all units of the federation, territorial spaces and their components to be specially protected, with alteration and* ***suppression only allowed by law****, and any use that compromises the integrity of the attributes that justify their protection being forbidden" (Brasil, 1988)*. This precept is regulated by Law 9.985/2000, which established the National System of Nature Conservation Units - SNUC.

The federal law Nº 9,985/2000 also (Brasil, 2000) creates the National System of Conservation Units (Sistema Nacional de Unidades de Conservação – SNUC). By themselves, the Conservation Units (UC) may range from fully protected, where human use is restricted, to those of sustainable use, where economic exploitation compatible with environmental conservation is permitted. According to it, the classification of Conservation Units for Sustainable Use has the Area of Environmental Protection (Área de Proteção Ambiental – APA) as one of its kind. After the SNUC conception as a mechanism of environmental protection, the Pará State Law Nº2,612/2006 (SEMA, 2006) created the APA Triunfo do Xingu, where the project's properties are located. Configuring as a Conservation Unit, tree articles from the SNUC legislation are relevant to be considered about forest management activities inside the property in the Legal Reserve area:

"Art. 14 - The following conservation unit categories constitute the Sustainable Use Units Group:

I - Environmental Protection Area;"

(...)

Art. 15. The Environmental Protection Area is a generally extensive area, with a certain degree of occupation human, endowed with abiotic, biotic, aesthetic or cultural attributes especially important for the quality of life and the well-being of human populations, and its basic objectives are to protect the biological diversity, discipline the occupation process and ensure the sustainability of the use of natural resources.

(...)

Art. 27. Conservation units must have a Management Plan.

(...)

§ 2 In the preparation, updating and implementation of the Management Plan for Extractive Reserves, Sustainable Development Reserves, Environmental Protection Areas and, when applicable, the National Forests and Areas of Relevant Ecological Interest, the broad participation of the resident population.

§ 3 The Management Plan for a conservation unit must be prepared within five years from the date of its creation."

Article 15 of the SNUC is regulated by Decree 4.340/2002. Therefore, it is understandable that there is the possibility of exploitation of forest products, including timber, in accordance with the redaction given to article 25 of the aforementioned decree, below in verbs:

"Art. 25 - The exploration of products, sub-products or services inherent to the conservation units is subject to authorization, in accordance with the objectives of each unit category.

Sole paragraph. For the ends of this Decree, products, sub-products or services inherent to conservation units are understood as follows

(...)

II - the exploitation of forest resources and other natural resources in Sustainable Use Conservation Units, within the limits established by law." (Brasil, 2002a)

At last, the Law Nº 11,284/2006 (Brasil, 2006) have in its article 83 the requirement of an approval from the state public environmental agency to execute forest management activities in the forested area. Accordingly, in the light of the above, it is understood that even without a management plan to establish the norms that guide the use of the natural resources within the APA, there is legal basis for the approval of a management plan for the area. However, if the competent body denies this, it is possible to appeal to the Judiciary to guarantee compliance with these norms.

To reinforce the legal argument presented above that even though the APA does not yet have an approved management plan, it is possible to observe that other SFMPs have already been approved within the APA (Figure 3.42).

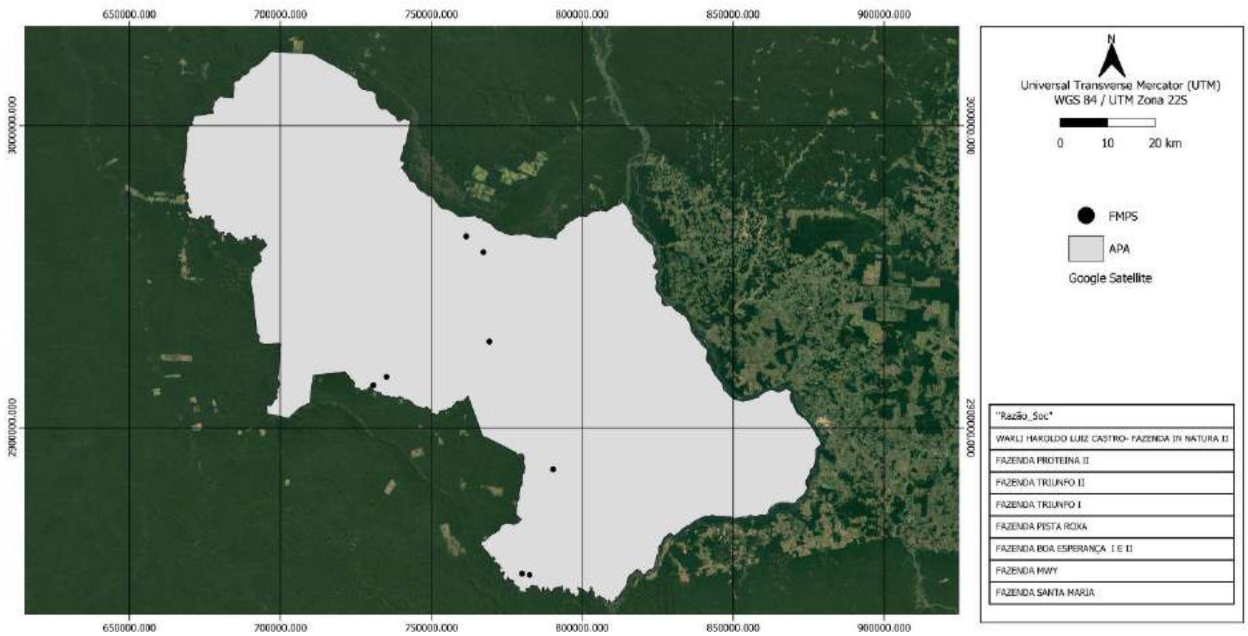


Figure 3.42 Approved Forest Management Plans inside APA Triunfo do Xingu (SEMAS, 2023)

It is also worth mentioning that in the specific case of landowner Rafael Sefer's farms, for this scenario to be considered credible and for the approval of a sustainable forest management plan, there is the need for the conclusion of the due land regularization process within ITERPA.

Considering all this legal framework, the conclusion is that despite the project area configuring a LR area inside an APA conservation unit, forest management activities could occur. The main requirement to it is the approval of a Sustainable Forest Management Plan (Plano de Manejo Florestal Sustentável – SFMP) by the competent environmental agency, and even without a management plan to establish the norms that guide the use of the natural resources within the APA, there is legal basis for the approval of a management plan for the area. Then, this scenario needs to be considered as a baseline credible option.

Sub-step 1c. Selection of baseline scenario

Based on the identified drivers of deforestation described in section 3.4 and all the common practices and the BAU scenario, the most credible scenario for TdX to happen without the revenue of the carbon credits would be **scenario (i),** the continuation of the pre-project land use scenario.

Scenario (ii) is easily rejected considering that it would add only costs to the landowners, and no additional revenue to them.

Scenario (iii) was discarded mainly because of the lack of local infrastructure for the forest management production chain, resulting in higher investments and lower incomes. This affirmation is done after talking to the landowners and understanding their practical difficulties to implement a forest management regime. Also, literature research was made to better understand the scenario. According to da Silva, de Almeida, and de Souza Pompermaye (2014), one of the main causes of disincentive forest management is the high cost of log transportation from the forest to the sawmill, representing 40% of the total logging costs. In addition, the lack of supervision over illegal timber and the bureaucracy for issuing a forest management plan makes legal timber to be less competitive in local markets.

Corroborating this analysis, (Bartholomeu, Vencovsky, Péra, Nunes, & Caixeta-Filho, 2012) made a detailed assessment of the main waterways, highways, and ports necessary for wood production transportation. The result is that there are bottlenecks involving each one of them: some highways are still not asphalted, are lacking signage and bridges are in poor conditions, some waterways have strong river currents and are poorly integrated with other modes of transport, some ports also are not asphalted, don't have access ramps and cargo transport equipment. Summing up those facts, scenario (iii) was discarded.

3.5.2 Step 2. Investment analysis

The proposed project activity, without the revenue from the sales of VCUs, is financially less attractive than scenario 1 (defined as the BAU scenario), to demonstrate that, according to VT0001 (VERRA, 2012b), an investment analysis will be performed.

Sub-step 2a. Determine appropriate analysis method

According to VT0001 (VERRA, 2012b), to determine whether to apply simple cost analysis, investment comparison analysis or benchmark analysis, it's required to identify if the VCS AFOLU project generates no financial or economic benefits other than VCS related income.

As the VCS AFOLU project does not generate any financial or economic benefits other than VCS related income, it was applied the simple cost analysis (Option I).

Sub-step 2b. – Option I. Apply simple cost analysis

The costs to implement REDD+ activities involve community engagement, monitoring and surveillance of the property's areas against illegal squatters, a decent infrastructure for the local workers, etc. All the most relevant costs for implementing structured monitoring, surveillance, and fire protection system were identified in partnership with the landowners and are described in Table 3.30 and Table 3.31 below. Supporting financial information is available attached[103].

Table 3.30 General CAPEX for infrastructure and equipment.

CAPEX	Unit cost [R$]	Units required	Total cost [R$]
Planning of the proposed activities	R$ 144.880,00	1	R$ 144.880
Social Diagnosis	R$ 138.000,00	1	R$ 138.000
Forest inventory	R$ 235.000,00	1	R$ 235.000
Fauna Inventory	R$ 348.671,14	1	R$ 348.671
Vehicles	R$ 277.591,00	1	R$ 277.591
Signaling Plate	R$ 417,59	20	R$ 8.352

[103] Annex: 230314_Simple_costs.zip

CAPEX	Unit cost [R$]	Units required	Total cost [R$]
Motorcycle	R$ 29,645.00	2	R$ 59,290

Table 3.31 General OPEX for maintaining the surveillance and monitoring system

OPEX [R$]	Annual cost/unit	Units required	Total annual cost [R$]
Field Team	R$ 25.740,00	2	R$ 51.480,00
Vehicle Fuel	R$ 3.000,00	2	R$ 6.000,00
Generator Fuel	R$ 14.600,00	1	R$ 14.600,00
Motorcycle Fuel	R$ 2.400,00	2	R$ 4.800,00
Motorcycle Maintance	R$ 12.000,00	2	R$ 24.000,00
Surveillance and Patrolling	R$ 42.900,00	2	R$ 85.800,00
Courses and Training (Fire Brigade)	R$ 20.000,00	2	R$ 40.000,00
Social Investments (activities)	R$ 100.000,00	1	R$ 100.000,00
Remote Monitoring	R$ 65.000,00	1	R$ 65.000,00
Firebreak maintance (R$/km)	R$ 1.000,00	115	R$ 115.000,00
Stakeholder consultation and community engagement	R$ 75.000,00	1	R$ 75.000,00

Considering that the AFOLU Project activity does not generate any financial or economic benefits other than VCS related income, as the conservation of the project area is an obligation defined by law without any financial incentive available for the APA Triunfo do Xingu, without the revenues of carbon credits, a systematic conservation activity for the areas would not be possible to occur.

3.5.3 Step 3. Barrier Analysis

The VT0001 (VERRA, 2012b) requires investment analysis (Step 2) or Barrier Analysis (Step 3). In this case, we opted for the Investment Analysis, already described in Step 2.

3.5.4 Step 4. Common practices analysis

The practice of implementing a structured monitoring system by private landowners in the Amazon without the benefit of carbon credits is a rare practice, being commonly observed on public lands, by measures adopted by the State Governments for biodiversity conservation. The APA Triunfo do Xingu was created in 2006, but without an approved management plan regulating the use of the APA, nor any indication of conservation mechanisms that should be followed by private landowners.

The SNUC law allows the creation of conservative units in private lands (e.g. Private Reserve of Natural Heritage - *Reserva Particular do Patrimônio Natural* - RPPN), other mechanisms such as environmental servitude (Law Nº 6,938, 1981 (Brasil, 1981)) and payment for environmental services (Law Nº 14,119, 2021 (Brasil, 2021)) can be seen as mechanisms for preserving and encouraging owners to take similar measures, however less effectively compared to a REDD+ project. In the case of Environmental servitude, however, the benefits are limited to 20% of the land that the landowner has the right to explore, being the preservation activity applied to an area essentially distinct from the AFOLU project area. The implementation of payment for environmental services in the region is not yet effective to implement the proposed VCS AFOLU project activities, as the financial barrier exists while there were only found 5 institutional projects in Pará State but with no reports of the same proposed VCS AFOLU project activity (PTS, 2022).

According to the Brazilian government, the RPPN are important because contribute to the expansion of protected areas in the country; have highly positive indices for conservation, especially if considered the cost and benefit ratio; are easily created in relation to the other categories of UC; enable the participation of private initiative in the national conservation effort; contribute to the protection of the biodiversity of Brazilian biomes. The general benefits of adhering to the program are preserved property rights; exemption from the ITR related to the area created as RPPN; priority in the analysis of projects by the National Environment Fund (FNMA); preference in the analysis of agricultural credit applications, with official credit institutions, for projects to be implemented in properties that contain RPPN in its perimeter; possibilities of cooperation with private and public entities in the protection, and management of the Unit (ICMBio, 2020). Despite being apparently beneficial to landowners, the creation of an RPPN on the property is ineffective to stop local deforestation, considering both the high cost of opportunity in the face of cattle ranching, as well as the dismantling of environmental agencies seen in recent years in Brazil. It is also a mechanism that presents essential distinctions between the proposed AFOLU project activity, as the resources from the RPPN are insignificant given the REDD+ project costs, and there is no MRV-A system that would give the landowner any capability in implementing a structured monitoring and surveillance system around the properties. Furthermore, no RPPN records were found in Altamira nor in Félix do Xingu (ICMBio, 2022).

The main alternative mechanism for carbon credit in the Amazon comes from the **Amazon Fund**, which "is a REDD+ mechanism created to raise donations for non-reimbursable investments in efforts to prevent, monitor and combat deforestation, as well as to promote the preservation and sustainable use in the Brazilian Amazon" (FundoAmazonia, 2022). However, there are some fundamental differences between the accounting and financing mechanism of projects available in Amazon fund versus the VCS REDD+ projects. In the first one, the project would only be possible if it was provided within the available budget of the fund, furthermore, the mechanism of accounting for the GHG emissions reductions adopts different MRV-A mechanisms, besides that the program has had no more projects approval since 2019 (CNN, 2022).

In an analysis of the base data of the VCS registry, made on 10/03/2022, 23 projects registered in Brazil with some REDD activity being developed were identified, and 55 projects in total considering registered projects and pipeline projects. Of the 23 registered, the projects are in the states of Acre, Amapá, Amazonas, Pará, Mato Grosso, and Mato Grosso do Sul, States with a predominance of the Amazon biome, except for Mato Grosso do Sul. Considering the extensions of the state of Pará, no REDD+ project recorded in the VERRA registry database for the APA Triunfo do Xingu region was identified, thus characterizing an unusual practice for the region.

As it's possible to observe there are some forest conservation mechanisms available in the market with a limited applicability range, and with essential distinctions between the proposed VCS AFOLU project activity and with low effectiveness in avoiding deforestation, especially to the APA Triunfo do Xingu, the proposed VCS AFOLU project activity is not the baseline scenario and, hence, the TdX REDD+ Grouped Project is additional.

3.6 Methodology Deviations

No methodology deviations were made in the design and development of the project until the completion of this document.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

The carbon stock changes and GHG emission estimation in baseline were made beside modules VM0015 Methodology for Avoided Unplanned Deforestation, v1.1 (VERRA, 2012a). The Triunfo do Xingu (TdX) project has a total area of 10,636.02 ha of forest. The project proponent is the Systemica company (MYS E JLFL TREINAMENTO GERENCIAL LTDA). The project area (Figure 4.1) is composed of (i) 9,229.23 ha with one owner called Rafael Sefer distributed by six farms denominated: *Patacho, Campo Lindo, Belcon, Santa Marta, Retiro Encantado,* and *Vó Lina*; and (ii) 1,406.79 ha with the other owner called Didário Barros owner of *Nossa Senhora Aparecida* farm, totaling 10,636.02 ha project area. Since the project is a grouped project, the information at this time only applies to the first instance. If more instances are added later, in this case, it will be reported in the future monitoring report or baseline reassessment. The project start date is August 31, 2022, with 6-year first baseline period until August 30, 2028. The total project period is 30 years lasting until August 30, 2052 (Figure 4.1).

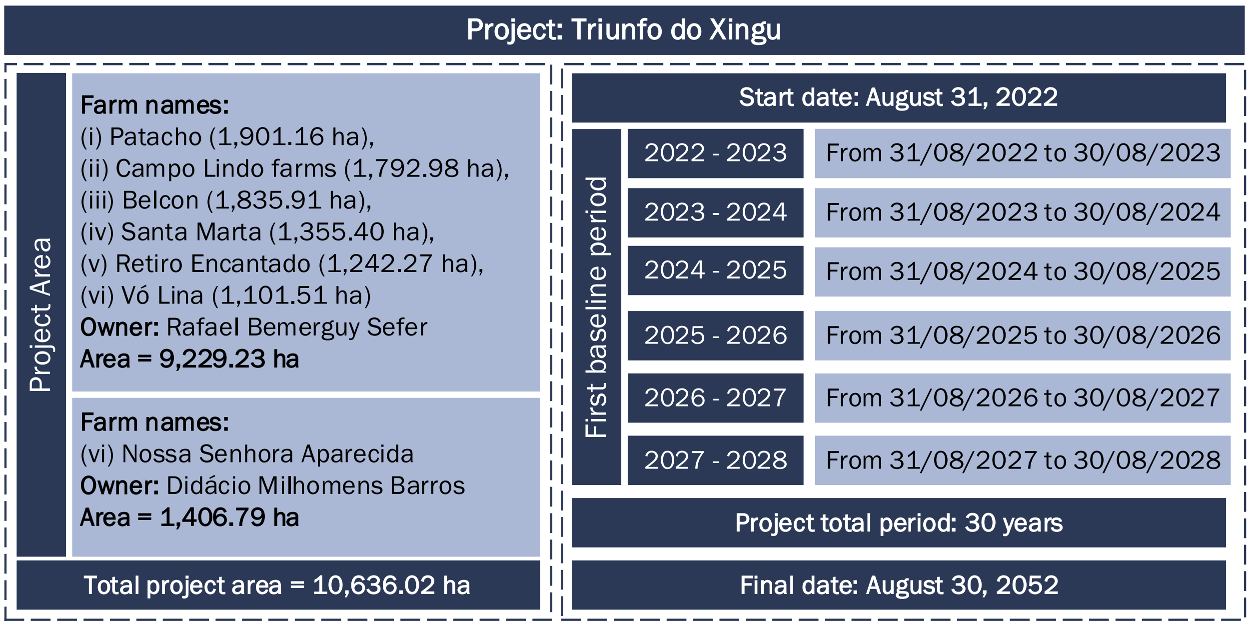


Figure 4.1. Triunfo do Xingu (TdX) project area and summary date information.

Non-CO_2 emissions from fires used to clear forests can be counted when sufficient data are available to estimate them. However, accounting for these emissions was conservatively omitted in this project. GHG emissions from land use implemented on deforested lands (including biomass burning) are conservatively omitted in the used VM0015 Methodology for Avoided Unplanned Deforestation, v1.1 (VERRA, 2012a).

The Triunfo do Xingu project total period estimation is represented in Table 4.1.

Table 4.1. Triunfo do Xingu project total period.

Triunfo do Xingu project period						
Period time (year)	1st baseline period	2022	From	31/08/2022	to	30/08/2023
		2023	From	31/08/2023	to	30/08/2024
		2024	From	31/08/2024	to	30/08/2025
		2025	From	31/08/2025	to	30/08/2026
		2026	From	31/08/2026	to	30/08/2027
		2027	From	31/08/2027	to	30/08/2028
	2nd baseline period	2028	From	31/08/2028	to	30/08/2029
		2029	From	31/08/2029	to	30/08/2030
		2030	From	31/08/2030	to	30/08/2031
		2031	From	31/08/2031	to	30/08/2032
		2032	From	31/08/2032	to	30/08/2033
		2033	From	31/08/2033	to	30/08/2034
	3rd baseline period	2034	From	31/08/2034	to	30/08/2035
		2035	From	31/08/2035	to	30/08/2036
		2036	From	31/08/2036	to	30/08/2037
		2037	From	31/08/2037	to	30/08/2038
		2038	From	31/08/2038	to	30/08/2039
		2039	From	31/08/2039	to	30/08/2040

	4th baseline period	2040	From	31/08/2040	to	30/08/2041
		2041	From	31/08/2041	to	30/08/2042
		2042	From	31/08/2042	to	30/08/2043
		2043	From	31/08/2043	to	30/08/2044
		2044	From	31/08/2044	to	30/08/2045
		2045	From	31/08/2045	to	30/08/2046
	5th baseline period	2046	From	31/08/2046	to	30/08/2047
		2047	From	31/08/2047	to	30/08/2048
		2048	From	31/08/2048	to	30/08/2049
		2049	From	31/08/2049	to	30/08/2050
		2050	From	31/08/2050	to	30/08/2051
		2051	From	31/08/2051	to	30/08/2052

4.1.1 Biomass estimation and calculation of baseline carbon stock changes[104]

In the initial phase of the project, baseline values were based on vegetation type collected from geospatial data (IBGE, 2022a; Nogueira, Yanai, Fonseca, & Fearnside, 2015). This parameter will be updated when the TdX project biomass inventory is made in the project area. The Standard Operating Procedure (SOP)[105] document describes biomass inventory planning.

The project is located in the Amazon Biome, Pará, Brazil. The biomass estimation in the project area was based on the relationship between geospatial data (IBGE, 2022a) and biomass data from the Amazon biome found in the literature (Nogueira et al., 2015). According to Nogueira et al. (2015), the many forest classes found in the Amazon biome are listed in Table 4.2. In this case, the values of the average biomass value of each Amazon Forest class are represented in Table 4.3. A conservative approach through uncertainty assessment and the percentage of error was used. In this case, if the uncertainty of the total average carbon stock is less than 10% of the average value, the average carbon stock value is used. Otherwise, the lower boundary of the 90% confidence interval is considered in the calculations. In this case, the conversion factor for a 90% confidence interval of 1.645 is used. Therefore, 90% confidence Intervals have been used to define whether the most suitable choice would be the average or the lower range limit, to mitigate uncertainties in estimates, as shown in Table 4.4.

Table 4.2. Forest classes in the Amazon biome

Initials	Forest Class
Da	Dense-canopy rainforest on river floodplain
Db	Dense-canopy rainforest on nonflooding lowlands
[a] Ds	**[a] Dense-canopy rainforest, submontane**
Pa	Pioneer vegetation in areas with riverine influence
Aa	Open-canopy rainforest on river floodplain

[104] Annex: 230214_ 4_Calculation of Net GHG Emission Reductions and Removals_30 years.xlsx

[105] Annex: 221014_ SOP - Standard Operating Procedure.pdf

Ab	Open-canopy rainforest on nonflooding lowlands
[a] As	**[a] Open-canopy rainforest, submontane**
Sd	Seasonal forested savanna
Sg	Seasonal grassy-woody savanna

[a] The vegetation type with occurrence in the project area.

The carbon component of dry matter of 0.47 tC t d.m^{-1} is used when converting biomass measured in Mg.ha^{-1} to tC.ha^{-1} (IPCC, 2006d). The value of $tCO_2e.ha^{-1}$ was obtained considering the molar weight of CO_2 (44 g.mol^{-1}) divided by C (12 g.mol^{-1}) Equation 10.

$$C_{ab_{icl}} = ab \times CF \times \frac{44}{12}$$ Equation 2

Where:

$C_{ab_{icl}}$	Average carbon stock per hectare in the aboveground biomass carbon pool of class icl; $tCO_2e.ha^{-1}$
ab	Average biomass stock per hectare in the aboveground biomass pool of initial forest class icl; Mg.ha^{-1}
CF	Default value of carbon fraction in biomass CF = 0.47 tC d.m^{-1} (IPCC, 2006d)
$44/12$	Ratio converting C to CO_2e

Table 4.3. The total value of biomass, carbon, and carbon dioxide equivalent for different forest classes according to Nogueira et al. (2015)

Initials	Aboveground biomass		Aboveground carbon		Aboveground carbon eq.		Belowground biomass		Belowground carbon		Belowground carbon eq		Total biomass		Total carbon		Total carbon eq	
	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
	$Mg.ha^{-1}$		$tC.ha^{-1}$		$tCO_2e.ha^{-1}$		$Mg.ha^{-1}$		$tC.ha^{-1}$		$tCO_2e.ha^{-1}$		$Mg.ha^{-1}$		$tC.ha^{-1}$		$tCO_2e.ha^{-1}$	
Da	299.26	63.52	140.65	29.85	515.72	109.47	71.82	15.24	33.76	7.17	123.77	26.27	371.08	78.76	174.41	37.02	639.50	135.74
Db	318.90	58.15	149.88	27.33	549.57	100.21	76.54	13.96	35.97	6.56	131.90	24.05	395.44	72.11	185.85	33.89	681.47	124.26
[a] Ds	319.59	76.72	150.21	36.06	550.76	132.21	76.70	18.41	36.05	8.65	132.18	31.73	396.29	95.13	186.26	44.71	682.94	163.95
Pa	19.68	2.37	9.25	1.11	33.92	4.08	3.94	0.47	1.85	0.22	6.78	0.82	23.62	2.84	11.10	1.34	40.70	4.90
Aa	298.39	60.66	140.24	28.51	514.23	104.54	71.61	14.56	33.66	6.84	123.41	25.09	370.00	75.22	173.90	35.35	637.64	129.63
Ab	303.10	57.66	142.46	27.10	522.34	99.37	72.74	13.84	34.19	6.50	125.36	23.85	375.84	71.50	176.65	33.60	647.70	123.22
[a] As	280.24	64.38	131.71	30.26	482.95	110.95	67.26	15.45	31.61	7.26	115.91	26.63	347.50	79.83	163.32	37.52	598.85	137.58
Sd	51.29	21.46	24.11	10.09	88.39	36.98	10.26	4.29	4.82	2.02	17.68	7.40	61.55	25.75	28.93	12.10	106.07	44.38
Sg	6.95	2.70	3.27	1.27	11.98	4.65	1.39	0.54	0.65	0.25	2.40	0.93	8.34	3.24	3.92	1.52	14.37	5.58

[a] The vegetation type with occurrence in the project area.

Table 4.4. The corrected values with uncertainty assessment

	Uncertainty assessment														
	Total carbon eq					Aboveground carbon eq.					Belowground carbon eq				
Initial	% error	[a] ± 90%	$tCO_2e.ha^{-1}$	$tC.ha^{-1}$	$Mg.ha^{-1}$	% error	[a] ± 90%	$tCO_2e.ha^{-1}$	$tC.ha^{-1}$	$Mg.ha^{-1}$	% error	[a] ± 90%	$tCO_2e.ha^{-1}$	$tC.ha^{-1}$	$Mg.ha^{-1}$
Da	21%	223.29	416.21	113.51	241.51	21%	180.07	335.65	91.54	194.77	21%	43.22	80.56	21.97	46.74
Db	18%	204.41	477.06	130.11	276.82	18%	164.85	384.72	104.92	223.24	18%	39.56	92.33	25.18	53.58
[a] Ds	24%	269.69	413.25	112.71	239.80	24%	217.49	333.27	90.89	193.39	24%	52.20	79.98	21.81	46.41
Pa	12%	8.06	32.64	8.90	18.94	12%	6.72	27.20	7.42	15.78	12%	1.34	5.44	1.48	3.16
Aa	20%	213.24	424.40	115.75	246.27	20%	171.96	342.26	93.34	198.60	20%	41.27	82.14	22.40	47.67
Ab	19%	202.69	445.01	121.37	258.23	19%	163.46	358.88	97.88	208.25	19%	39.23	86.13	23.49	49.98
[a] As	23%	226.31	372.54	101.60	216.18	23%	182.51	300.44	81.94	174.33	23%	43.80	72.10	19.66	41.84
Sd	42%	73.00	33.06	9.02	19.19	42%	60.84	27.55	7.51	15.99	42%	12.17	5.51	1.50	3.20
Sg	39%	9.19	5.19	1.41	3.01	39%	7.65	4.32	1.18	2.51	39%	1.53	0.86	0.24	0.50

[a] Considering the conversion factor for a 90% confidence interval of 1.645 (Nogueira et al., 2015).

Belowground biomass of trees is recommended, as it usually represents between 15% and 30% of the aboveground biomass. The aboveground is converted into belowground biomass through a root-shoot ratio. This value is 0.20 for above-ground biomass less than 125 $t.ha^{-1}$ and 0.24 for aboveground biomass greater than 125 $t.ha^{-1}$, according to VM0015 Methodology for Avoided Unplanned Deforestation (VERRA, 2012a), v1.1 (IPCC, 2006d). The average carbon stock per hectare in the below-ground biomass carbon pool of class is determined by Equation 8.

$$C_{bb_{icl}} = bb \times CF \times \frac{44}{12}$$ Equation 3

Where:

$C_{bb_{icl}}$	Average carbon stock per hectare in the belowground biomass carbon pool of class icl; $tCO_2e.ha^{-1}$
bb	Average biomass stock per hectare in the belowground biomass pool of initial forest class icl; $Mg.ha^{-1}$
CF	Default value of carbon fraction in biomass CF = 0.47 tC $d.m^{-1}$ (IPCC, 2006d)
44/12	Ratio converting C to CO_2e

According to IBGE (2022a), the classes found in the project area are: (i) *Floresta Ombrófila Aberta Submontana*; (ii) *Contato* defined by the transition between *Floresta Ombrófila Aberta* and *Floresta Ombrófila Densa*; and, (iii) *Floresta Ombrófila Densa Submontana*. A conservative approach is used considering *Contato* being just *Floresta Ombrófila Aberta Submontana* class. Comparing the IBGE (2022a) database with Nogueira et al. (2015) database the classes *Floresta Ombrófila Aberta Submontana* was considered with Open-canopy rainforest, submontane (As) and *Floresta Ombrófila Densa Submontana* was denominated Dense-canopy rainforest, submontane (Ds). Therefore, the As and Ds Forest classes were highlighted in bold in Table 4.3 and Table 4.4 and used in the calculations. The resultant values are represented in Table 4.5.

Table 4.5. Resultant values of biomass for each vegetation type

Parameter	Unit	Vegetation type	
		Open-canopy rainforest, submontane	Dense-canopy rainforest, submontane
ab	$Mg.ha^{-1}$	174.33	193.39
bb	$Mg.ha^{-1}$	41.84	46.41
Percentage of belowground in relation total	%	19.35	19.35
C_{abicl}	$tCO_2e.ha^{-1}$	300.44	333.27
C_{bbicl}	$tCO_2e.ha^{-1}$	72.10	79.98
$C_{totalicl}$	**$tCO_2e.ha^{-1}$**	372.54	413.25

According to the methodology VM0015, the Historical LU/LC-change (Method 1) was used to calculate the LU/LC class that will replace the forest cover in the baseline scenario. The total baseline carbon stock changes in the project area at year are calculated considering the total baseline carbon stock change for the above-

/below-ground biomass pool in the project area for the initial forest class (Equation 4) (. Equation 10 on page 72 of VM0015 v.1.1 has been simplified and split into Equation 4).

$$\Delta CBSLPA_t = \sum_{p=1}^{P}\left(\sum_{icl=1}^{Icl} ABSLPA_{icl,t} * \Delta Cp_{icl,t=t*} - \sum_{z=1}^{Z} ABSLPA_{z,t} * \Delta Cp_{z,t=t*} + \sum_{icl=1}^{Icl} ABSLPA_{icl,t-1} * \Delta Cp_{icl,t=t*+1} - \sum_{z=1}^{Z} ABSLPA_{z,t-1} * \Delta Cp_{z,t=t*+1} + \sum_{icl=1}^{Icl} ABSLPA_{icl,t-2} * \Delta Cp_{icl,t=t*+2} - \sum_{z=1}^{Z} ABSLPA_{z,t-2} * \Delta Cp_{z,t=t*+2} + \cdots + \sum_{icl=1}^{Icl} ABSLPA_{icl,t-19} * \Delta Cp_{icl,t=t*+19} - \sum_{z=1}^{Z} ABSLPA_{z,t-19} * \Delta Cp_{z,t=t*+19}\right) \quad \text{Equation 4}$$

Where:

$\Delta CBSLPA_t$	Total baseline carbon stock change within the project area at year t; tCO_{2-e}
$ABSLPA_{icl,t}$	Area of initial forest class icl deforested at time t within the project area in the baseline case; ha
$ABSLPA_{icl,t-1}$	Area of initial forest class icl deforested at time t-1 within the project area in the baseline case; ha
$ABSLPA_{icl,t-19}$	Area of initial forest class icl deforested at time t-19 within the project area in the baseline case; ha
$\Delta Cp_{icl,t=t*}$	Average carbon stock change factor for carbon pool p in the initial forest class icl applicable at time t; tCO_{2-e} ha^{-1}
$\Delta Cp_{icl,t=t*+1}$	Average carbon stock change factor for carbon pool p in the initial forest class icl applicable at time t=t*+1 (= 2nd year after deforestation); tCO_{2-e} ha^{-1}
$\Delta Cp_{icl,t=t*+19}$	Average carbon stock change factor for carbon pool p in the initial forest class icl applicable at time t=t*+19 (20th year after deforestation); tCO_{2-e} ha^{-1}
$ABSLPA_{z,t}$	Area of the zone z “deforested” at time t within the project area in the baseline case; ha
$ABSLPA_{z,t-1}$	Area of the zone z “deforested” at time t-1 within the project area in the baseline case; ha
$ABSLPA_{z,t-19}$	Area of the zone z “deforested” at time t -19 within the project area in the baseline case; ha
$\Delta Cp_{z,t=t*}$	Average carbon stock change factor for carbon pool p in zone z applicable at time t = t*; tCO_{2-e} ha^{-1}
$\Delta Cp_{z,t=t*+1}$	Average carbon stock change factor for carbon pool p in zone z applicable at time t = t*+1 (= 2nd year after deforestation); tCO_{2-e} ha^{-1}

$\Delta Cp_{z,t=t*+19}$	Average carbon stock change factor for carbon pool p in zone z applicable at time t = t*+19 ((= 20th year after deforestation); tCO_{2-e} ha^{-1}
icl	1, 2, 3 … Icl initial (pre-deforestation) forest classes; dimensionless
z	1, 2, 3 … Z zones; dimensionless
p	1, 2, 3 … P carbon pools included in the baseline; dimensionless
t	1, 2, 3 … T, a year of the proposed project crediting period; dimensionless
t^*	the year at which the area $ABSLPA_{icl,t}$ is deforested in the baseline case

Equation 4 was applied to above-ground and below-ground. Additionally, this equation was applied to the leakage belt area and reference region.

The project area is separated into Didácio and Rafael Sefer owners. A more representative and conservative approach is taken to leakage belt determination (see Section 3.3 and Section 3.4). In this case, the leakage belt area is determined by a buffer around the project area considering the farms of Rafael Sefer and Didácio along with opportunity cost analysis. The boundary of the reference region is the spatial delimitation of the analytic domain from which information about rates, agents, drivers, and patterns of land-use and land-cover change (LU/LC-change) will be obtained, projected into the future, and monitored. The reference region contains strata with agents, drivers, and deforestation patterns that, in the 10-15 years period before the start date of the proposed AUD project activity are similar to those expected to exist within the project area (see Section 3.3). The area of the initial forest class deforested within the project area, leakage belt, and reference region in the baseline case is estimated through location analysis (modeling [106] [107]) as described in Section 3.4, and these areas are presented in Table 4.6.

It should be emphasized that the TdX project area is located in Altamira municipality, Pará state, considered the most deforested in the Legal Amazon region of Brazil in 2021 (G1, 2021). As reported previously, the Triunfo do Xingu conservation unit (Área de Proteção Ambiental - APA), is located around the project area in the municipalities of São Félix do Xingu and Altamira, in Pará. According to IMAZON (2022a), the deforestation pressure manifests within the "Areas Protegidas" (APs, preservation areas), leading to losses of environmental services and even the reducing or resetting APs limits. That is, it is an internal process that can lead to legal and environmental destabilization of the APs. The annual deforestation in the Altamira municipality is reported in Figure 4.2. Deforestation has increased in the last three years, with an average deforestation rate of over 71,277 ha $year^{-1}$ (TerraBrasilis, 2022). As evidenced in Section 3.4, deforestation in the reference region presents the linear adjustment at time function according to VM0015 (VERRA, 2012a). The approach "b" is used for allocation analysis of the ABSLRR in the project area conforming to represent the modeling in Figure 4.2. According to the modeling

[106] Annex: 221020_TDX-GIS_DATA_PROCEDURES.zip

[107] Annex: 221020_TDX-BASELINE_MODELING.zip

described in Section 3.4, the aggressive deforestation rate results in the total project area deforestation until 2032.

In this first analysis, the ABSL projected for RR, PA, and LK is zero from 2032. This information is evidence of the paramount importance of this REDD project in this region. Therefore, in this Project Description: VCS Version document, the quantification of GHG emission reductions and removals will be presented for 30 years estimation. However, the baseline estimation needs reassessment in the future to understand if this aggressive tendency will continue.

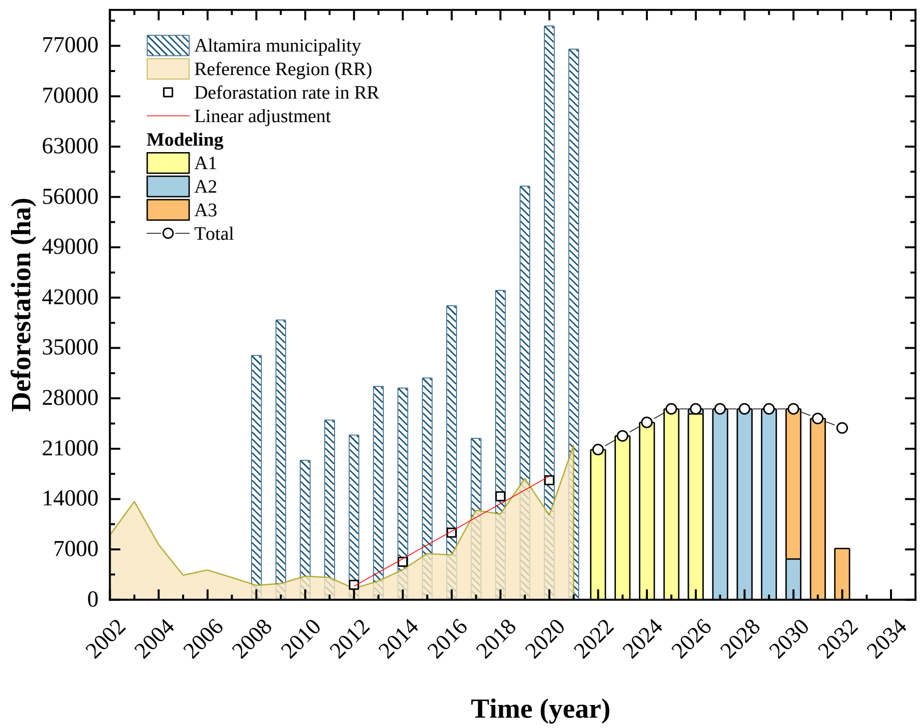


Figure 4.2. Deforestation over time in Altamira municipality (TerraBrasilis, 2022), in reference region and the allocation modeling in the project area.

Table 4.6. The deforested project area estimated by location analysis.

Area name / Stratum			Project Area									
			Didácio		Rafael Sefer		Total Project Area		Leakage Belt		Reference Region	
			As	Ds	As	Ds	As	Ds	As	Ds	As	Ds
Period time (year)	1st baseline period	2022	0.36	-	94.77	-	95.13	-	423.00	4.14	6,406.56	14,505.93
		2023	90.45	34.20	1,324.89	-	1,415.34	34.20	521.28	142.74	6,599.25	16,376.31
		2024	123.21	205.65	689.40	-	812.61	205.65	722.43	56.97	8,384.58	15,654.96
		2025	1.08	73.26	577.80	-	578.88	73.26	1,722.51	4.68	9,109.44	17,776.53
		2026	11.07	27.45	1,205.55	-	1,216.62	27.45	1,889.37	33.57	11,074.59	17,298.54
		2027	210.69	149.13	1,348.11	-	1,558.80	149.13	557.28	-	10,082.16	18,792.90
	2nd baseline period	2028	0.18	106.92	670.50	-	670.68	106.92	964.98	-	8,604.54	19,320.57
		2029	10.62	22.50	2,313.81	-	2,324.43	22.50	1,148.85	2.34	13,794.12	14,557.23
		2030	8.19	205.83	371.88	-	380.07	205.83	383.85	62.01	27,285.84	1,926.27
		2031	14.94	111.06	632.52	-	647.46	111.06	1,163.43	36.45	20,506.68	1,632.78
		2032	-	-	-	-	-	-	-	-	-	-
		2033	-	-	-	-	-	-	-	-	-	-
	3rd baseline period	2034	-	-	-	-	-	-	-	-	-	-
		2035	-	-	-	-	-	-	-	-	-	-
		2036	-	-	-	-	-	-	-	-	-	-
		2037	-	-	-	-	-	-	-	-	-	-
		2038	-	-	-	-	-	-	-	-	-	-
		2039	-	-	-	-	-	-	-	-	-	-
	4th baseline period	2040	-	-	-	-	-	-	-	-	-	-
		2041	-	-	-	-	-	-	-	-	-	-
		2042	-	-	-	-	-	-	-	-	-	-
		2043	-	-	-	-	-	-	-	-	-	-
		2044	-	-	-	-	-	-	-	-	-	-
		2045	-	-	-	-	-	-	-	-	-	-
	5th baseline period	2046	-	-	-	-	-	-	-	-	-	-
		2047	-	-	-	-	-	-	-	-	-	-
		2048	-	-	-	-	-	-	-	-	-	-
		2049	-	-	-	-	-	-	-	-	-	-
		2050	-	-	-	-	-	-	-	-	-	-
		2051	-	-	-	-	-	-	-	-	-	-
			470.79	936.00	9,229.23	-	9,700.02	936.00	9,496.98	342.90	121,847.76	137,842.02

As and *Ds* is Open-canopy rainforest, submontane and Dense-canopy rainforest, submontane vegetation type, respectively

To facilitate the interpretation of the results, Table 21.a 1-2, Table 21.b 1-2 and Table 21.c 1-2 of methodology VM0015 v1.1, are represented here by Table 4.7 and Table 4.8 (project area), Table 4.9 and Table 4.10 (leakage belt area), Table 4.11 and Table 4.12 (reference region). The final values of the total baseline carbon stock change for the above/belowground biomass pool in the project, leakage belt, and reference region at year t are presented in Table 4.13.

Table 4.7. Baseline carbon stock change in the above-ground biomass in the project area.

	Carbon stock changes in the above-ground biomass per initial forest class icl		Total carbon stock change in the above-ground biomass of the initial forest classes in the project area		Carbon stock changes in above-ground biomass per post-deforestation zone z		Total carbon stock change in the above-ground biomass of post-deforestation zones in the project area		Total net carbon stock change in the above-ground biomass of the project area	
ID_{icl}	1	2	$\Delta Cab\ BSLPA_{icl,t}$	$\Delta Cab\ BSLPA_{icl}$	1	2	$\Delta Cab\ BSLPA_{z,t}$	$\Delta Cab\ BSLPA_{z,t}$	$\Delta Cab\ BSLPA_{t}$	$\Delta Cab\ BSLPA$
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2022	28,580.59	-	28,580.59	28,580.59	1,290.21	-	1,290.21	1,290.21	27,290.37	27,290.37
2023	425,220.71	11,397.76	436,618.47	465,199.05	19,195.74	463.84	19,659.58	20,949.79	416,958.89	444,249.26
2024	244,138.23	68,536.53	312,674.76	777,873.82	11,021.13	2,789.16	13,810.29	34,760.08	298,864.47	743,113.74
2025	173,917.05	24,415.20	198,332.26	976,206.07	7,851.14	993.60	8,844.74	43,604.82	189,487.52	932,601.26
2026	365,517.84	9,148.20	374,666.04	1,350,872.11	16,500.57	372.29	16,872.87	60,477.68	357,793.18	1,290,394.43
2027	468,321.42	49,700.23	518,021.66	1,868,893.77	21,141.43	2,022.60	23,164.03	83,641.71	494,857.63	1,785,252.06
2028	201,497.18	35,633.00	237,130.18	2,106,023.95	9,096.19	1,450.12	10,546.30	94,188.01	226,583.88	2,011,835.94
2029	698,345.11	7,498.53	705,843.64	2,811,867.59	31,525.39	305.16	31,830.55	126,018.56	674,013.09	2,685,849.03
2030	114,187.15	68,596.52	182,783.67	2,994,651.26	5,154.75	2,791.60	7,946.35	133,964.91	174,837.32	2,860,686.35
2031	194,521.03	37,012.73	231,533.76	3,226,185.02	8,781.26	1,506.27	10,287.53	144,252.44	221,246.23	3,081,932.58
2032	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2033	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2034	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2035	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2036	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2037	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2038	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2039	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2040	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2041	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58

	Carbon stock changes in the above-ground biomass per initial forest class icl		Total carbon stock change in the above-ground biomass of the initial forest classes in the project area		Carbon stock changes in above-ground biomass per post-deforestation zone z		Total carbon stock change in the above-ground biomass of post-deforestation zones in the project area		Total net carbon stock change in the above-ground biomass of the project area	
ID_{icl}	1	2	$\Delta Cab\ BSLPA_{icl,t}$	$\Delta Cab\ BSLPA_{icl}$	1	2	$\Delta Cab\ BSLPA_{z,t}$	$\Delta Cab\ BSLPA_{z,t}$	$\Delta Cab\ BSLPA_{t}$	$\Delta Cab\ BSLPA$
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2042	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2043	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2044	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2045	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2046	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2047	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2048	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2049	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2050	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
2051	-	-	-	3,226,185.02	-	-	-	144,252.44	-	3,081,932.58
TOTAL	2,914,246.31	311,938.71	3,226,185.02		131,557.81	12,694.62	144,252.44		3,081,932.58	

Table 4.8. Baseline carbon stock change in the below-ground biomass in the project area.

	Carbon stock changes in the below-ground biomass per initial forest class icl		Total carbon stock change in the below-ground biomass of the initial forest classes in the project area		Carbon stock changes in below-ground biomass per post-deforestation zone z		Total carbon stock change in the below-ground biomass of post-deforestation zones in the project area		Total net carbon stock change in the below-ground biomass of the project area	
ID_{icl}	1	2	$\Delta Cbb\ BSLPA_{icl,t}$	$\Delta Cbb\ BSLPA_{icl}$	1	2	$\Delta Cbb\ BSLPA_{z,t}$	$\Delta Cbb\ BSLPA_{z}$	$\Delta Cbb\ BSLPA_{t}$	$\Delta Cbb\ BSLPA$
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2022	6,859.34	-	6,859.34	6,859.34	258.04	-	258.04	258.04	6,601.30	6,601.30
2023	102,052.97	2,735.46	104,788.43	111,647.77	3,839.15	92.77	3,931.92	4,189.96	100,856.52	107,457.81
2024	58,593.17	16,448.77	75,041.94	186,689.72	2,204.23	557.83	2,762.06	6,952.02	72,279.89	179,737.70
2025	41,740.09	5,859.65	47,599.74	234,289.46	1,570.23	198.72	1,768.95	8,720.96	45,830.79	225,568.49
2026	87,724.28	2,195.57	89,919.85	324,209.31	3,300.11	74.46	3,374.57	12,095.54	86,545.28	312,113.77
2027	112,397.14	11,928.06	124,325.20	448,534.50	4,228.29	404.52	4,632.81	16,728.34	119,692.39	431,806.16
2028	48,359.32	8,551.92	56,911.24	505,445.75	1,819.24	290.02	2,109.26	18,837.60	54,801.98	486,608.15
2029	167,602.83	1,799.65	169,402.47	674,848.22	6,305.08	61.03	6,366.11	25,203.71	163,036.36	649,644.51
2030	27,404.91	16,463.17	43,868.08	718,716.30	1,030.95	558.32	1,589.27	26,792.98	42,278.81	691,923.32
2031	46,685.05	8,883.05	55,568.10	774,284.40	1,756.25	301.25	2,057.51	28,850.49	53,510.60	745,433.92
2032	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2033	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2034	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2035	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2036	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2037	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2038	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2039	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2040	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2041	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92

	Carbon stock changes in the below-ground biomass per initial forest class icl		Total carbon stock change in the below-ground biomass of the initial forest classes in the project area		Carbon stock changes in below-ground biomass per post-deforestation zone z		Total carbon stock change in the below-ground biomass of post-deforestation zones in the project area		Total net carbon stock change in the below-ground biomass of the project area	
ID_{icl}	1	2	$\Delta Cbb\ BSLPA_{icl,t}$	$\Delta Cbb\ BSLPA_{icl}$	1	2	$\Delta Cbb\ BSLPA_{z,t}$	$\Delta Cbb\ BSLPA_{z}$	$\Delta Cbb\ BSLPA_{t}$	$\Delta Cbb\ BSLPA$
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2042	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2043	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2044	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2045	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2046	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2047	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2048	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2049	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2050	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
2051	-	-	-	774,284.40	-	-	-	28,850.49	-	745,433.92
TOTAL	699,419.11	74,865.29	774,284.40		26,311.56	2,538.92	28,850.49		745,433.92	

Table 4.9. Baseline carbon stock change in the above-ground biomass in the leakage belt area.

	Carbon stock changes in the above-ground biomass per initial forest class icl		Total carbon stock change in the above-ground biomass of the initial forest classes in the leakage belt area		Carbon stock changes in above-ground biomass per post-deforestation zone z		Total carbon stock change in the above-ground biomass of post-deforestation zones in the leakage belt area		Total net carbon stock change in the above-ground biomass of the leakage belt area	
ID_{icl}	1	2	$\Delta Cab\ BSLLK_{icl,t}$	$\Delta Cab\ BSLLK_{icl}$	1	2	$\Delta Cab\ BSLLK_{z,t}$	$\Delta Cab\ BSLLK_{z,t}$	$\Delta Cab\ BSLLK_{t}$	ΔCab BSLLK
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2022	127,084.91	1,379.73	128,464.64	128,464.64	5,736.99	56.15	5,793.14	5,793.14	122,671.50	122,671.50
2023	156,611.87	47,570.65	204,182.53	332,647.17	7,069.93	1,935.93	9,005.86	14,799.00	195,176.67	317,848.17
2024	217,044.81	18,986.27	236,031.08	568,678.24	9,798.05	772.66	10,570.72	25,369.72	225,460.36	543,308.52
2025	517,505.99	1,559.69	519,065.68	1,087,743.92	23,361.77	63.47	23,425.24	48,794.96	495,640.43	1,038,948.96
2026	567,636.93	11,187.80	578,824.73	1,666,568.65	25,624.83	455.30	26,080.13	74,875.09	552,744.60	1,591,693.56
2027	167,427.61	-	167,427.61	1,833,996.26	7,558.18	-	7,558.18	82,433.28	159,869.43	1,751,562.99
2028	289,915.84	-	289,915.84	2,123,912.10	13,087.67	-	13,087.67	95,520.95	276,828.17	2,028,391.15
2029	345,157.21	779.85	345,937.06	2,469,849.16	15,581.43	31.74	15,613.17	111,134.12	330,323.89	2,358,715.04
2030	115,322.80	20,665.94	135,988.74	2,605,837.90	5,206.02	841.02	6,047.04	117,181.15	129,941.70	2,488,656.74
2031	349,537.59	12,147.61	361,685.20	2,967,523.10	15,779.17	494.36	16,273.53	133,454.68	345,411.67	2,834,068.41
2032	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2033	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2034	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2035	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2036	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2037	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2038	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2039	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2040	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2041	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41

	Carbon stock changes in the above-ground biomass per initial forest class icl		Total carbon stock change in the above-ground biomass of the initial forest classes in the leakage belt area		Carbon stock changes in above-ground biomass per post-deforestation zone z		Total carbon stock change in the above-ground biomass of post-deforestation zones in the leakage belt area		Total net carbon stock change in the above-ground biomass of the leakage belt area	
ID_{icl}	1	2	$\Delta Cab\ BSLLK_{icl,t}$	$\Delta Cab\ BSLLK_{icl}$	1	2	$\Delta Cab\ BSLLK_{z,t}$	$\Delta Cab\ BSLLK_{z,t}$	$\Delta Cab\ BSLLK_{t}$	ΔCab BSLLK
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2042	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2043	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2044	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2045	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2046	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2047	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2048	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2049	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2050	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
2051	-	-	-	2,967,523.10	-	-	-	133,454.68	-	2,834,068.41
TOTAL	2,853,245.55	114,277.55	2,967,523.10		128,804.06	4,650.63	133,454.68		2,834,068.41	

Table 4.10. Baseline carbon stock change in the below-ground biomass in the leakage belt area.

	Carbon stock changes in the below-ground biomass per initial forest class icl		Total carbon stock change in the below-ground biomass of the initial forest classes in the leakage belt area		Carbon stock changes in below-ground biomass per post-deforestation zone z		Total carbon stock change in the below-ground biomass of post-deforestation zones in the leakage belt area		Total net carbon stock change in the below-ground biomass of the leakage belt area	
ID_{icl}	1	2	$\Delta Cbb\ BSLLK_{icl,t}$	$\Delta Cbb\ BSLLK_{icl}$	1	2	$\Delta Cbb\ BSLLK_{z,t}$	$\Delta Cbb\ BSLLK_{z}$	$\Delta Cbb\ BSLLK_{t}$	$\Delta Cbb\ BSLLK$
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2022	30,500.38	331.13	30,831.51	30,831.51	1,147.40	11.23	1,158.63	1,158.63	29,672.89	29,672.89
2023	37,586.85	11,416.96	49,003.81	79,835.32	1,413.99	387.19	1,801.17	2,959.80	47,202.63	76,875.52
2024	52,090.75	4,556.70	56,647.46	136,482.78	1,959.61	154.53	2,114.14	5,073.94	54,533.31	131,408.83
2025	124,201.44	374.33	124,575.76	261,058.54	4,672.35	12.69	4,685.05	9,758.99	119,890.71	251,299.55
2026	136,232.86	2,685.07	138,917.93	399,976.48	5,124.97	91.06	5,216.03	14,975.02	133,701.91	385,001.46
2027	40,182.63	-	40,182.63	440,159.10	1,511.64	-	1,511.64	16,486.66	38,670.99	423,672.45
2028	69,579.80	-	69,579.80	509,738.90	2,617.53	-	2,617.53	19,104.19	66,962.27	490,634.71
2029	82,837.73	187.16	83,024.89	592,763.80	3,116.29	6.35	3,122.63	22,226.82	79,902.26	570,536.98
2030	27,677.47	4,959.83	32,637.30	625,401.10	1,041.20	168.20	1,209.41	23,436.23	31,427.89	601,964.86
2031	83,889.02	2,915.43	86,804.45	712,205.54	3,155.83	98.87	3,254.71	26,690.94	83,549.74	685,514.61
2032	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2033	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2034	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2035	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2036	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2037	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2038	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2039	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2040	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2041	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61

	Carbon stock changes in the below-ground biomass per initial forest class icl		Total carbon stock change in the below-ground biomass of the initial forest classes in the leakage belt area		Carbon stock changes in below-ground biomass per post-deforestation zone z		Total carbon stock change in the below-ground biomass of post-deforestation zones in the leakage belt area		Total net carbon stock change in the below-ground biomass of the leakage belt area	
ID_{icl}	1	2	$\Delta Cbb\ BSLLK_{icl,t}$	$\Delta Cbb\ BSLLK_{icl}$	1	2	$\Delta Cbb\ BSLLK_{z,t}$	$\Delta Cbb\ BSLLK_{z}$	$\Delta Cbb\ BSLLK_{t}$	$\Delta Cbb\ BSLLK$
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2042	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2043	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2044	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2045	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2046	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2047	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2048	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2049	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2050	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
2051	-	-	-	712,205.54	-	-	-	26,690.94	-	685,514.61
TOTAL	684,778.93	27,426.61	712,205.54		25,760.81	930.13	26,690.94		685,514.61	

Table 4.11. Baseline carbon stock change in the above-ground biomass in the reference region.

	Carbon stock changes in the above-ground biomass per initial forest class icl		Total carbon stock change in the above-ground biomass of the initial forest classes in the reference region		Carbon stock changes in above-ground biomass per post-deforestation zone z		Total carbon stock change in the above-ground biomass of post-deforestation zones in the reference region		Total net carbon stock change in the above-ground biomass of the reference region	
ID_{icl}	1	2	ΔCab $BSLRR_{icl,t}$	ΔCab $BSLRR_{icl,t}$	1	2	ΔCab $BSLRR_{z,t}$	ΔCab $BSLRR_{z,t}$	ΔCab $BSLRR_{t}$	ΔCab $BSLRR_{t}$
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2022	1,924,768.59	4,834,360.11	6,759,128.70	6,759,128.70	86,889.82	196,738.61	283,628.43	283,628.43	6,475,500.27	6,475,500.27
2023	1,982,659.82	5,457,697.64	7,440,357.46	14,199,486.16	89,503.21	222,105.89	311,609.10	595,237.53	7,128,748.36	13,604,248.63
2024	2,519,039.27	5,217,294.87	7,736,334.14	21,935,820.31	113,716.98	212,322.48	326,039.47	921,277.00	7,410,294.68	21,014,543.31
2025	2,736,814.14	5,924,345.95	8,661,160.09	30,596,980.39	123,547.99	241,096.56	364,644.55	1,285,921.55	8,296,515.53	29,311,058.84
2026	3,327,218.19	5,765,047.25	9,092,265.44	39,689,245.83	150,200.60	234,613.76	384,814.36	1,670,735.91	8,707,451.08	38,018,509.93
2027	3,029,055.36	6,263,069.39	9,292,124.75	48,981,370.58	136,740.64	254,881.21	391,621.85	2,062,357.76	8,900,502.90	46,919,012.82
2028	2,585,123.43	6,438,924.84	9,024,048.26	58,005,418.85	116,700.22	262,037.81	378,738.03	2,441,095.79	8,645,310.24	55,564,323.06
2029	4,144,266.02	4,851,456.75	8,995,722.78	67,001,141.62	187,084.59	197,434.37	384,518.96	2,825,614.75	8,611,203.81	64,175,526.87
2030	8,197,679.85	641,963.86	8,839,643.71	75,840,785.33	370,067.84	26,125.29	396,193.14	3,221,807.89	8,443,450.58	72,618,977.45
2031	6,160,968.38	544,153.08	6,705,121.46	82,545,906.79	278,124.58	22,144.80	300,269.38	3,522,077.27	6,404,852.08	79,023,829.53
2032	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2033	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2034	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2035	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2036	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2037	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2038	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2039	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53

	Carbon stock changes in the above-ground biomass per initial forest class icl		Total carbon stock change in the above-ground biomass of the initial forest classes in the reference region		Carbon stock changes in above-ground biomass per post-deforestation zone z		Total carbon stock change in the above-ground biomass of post-deforestation zones in the reference region		Total net carbon stock change in the above-ground biomass of the reference region	
ID_{icl}	1	2	$\Delta Cab\ BSLRR_{icl,t}$	$\Delta Cab\ BSLRR_{icl,t}$	1	2	$\Delta Cab\ BSLRR_{z,t}$	$\Delta Cab\ BSLRR_{z,t}$	$\Delta Cab\ BSLRR_{t}$	$\Delta Cab\ BSLRR_{t}$
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2040	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2041	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2042	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2043	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2044	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2045	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2046	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2047	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2048	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2049	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2050	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
2051	-	-	-	82,545,906.79	-	-	-	3,522,077.27	-	79,023,829.53
TOTAL	36,607,593.06	45,938,313.74	82,545,906.79		1,652,576.49	1,869,500.78	3,522,077.27		79,023,829.53	

Table 4.12. Baseline carbon stock change in the below-ground biomass in the reference region.

	Carbon stock changes in the below-ground biomass per initial forest class icl		Total carbon stock change in the below-ground biomass of the initial forest classes in the reference region		Carbon stock changes in below-ground biomass per post-deforestation zone z		Total carbon stock change in the below-ground biomass of post-deforestation zones in the reference region		Total net carbon stock change in the below-ground biomass of the reference region	
ID_{icl}	1	2	$\Delta Cbb\ BSLRR_{icl,t}$	$\Delta Cbb\ BSLRR_{icl,t}$	1	2	$\Delta Cbb\ BSLRR_{z,t}$	$\Delta Cbb\ BSLRR_{z,t}$	$\Delta Cbb\ BSLRR_{t}$	$\Delta Cbb\ BSLRR_{t}$
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2022	461,944.46	1,160,246.43	1,622,190.89	1,622,190.89	17,377.96	39,347.72	56,725.69	56,725.69	1,565,465.20	1,565,465.20
2023	475,838.36	1,309,847.43	1,785,685.79	3,407,876.68	17,900.64	44,421.18	62,321.82	119,047.51	1,723,363.97	3,288,829.17
2024	604,569.43	1,252,150.77	1,856,720.19	5,264,596.87	22,743.40	42,464.50	65,207.89	184,255.40	1,791,512.30	5,080,341.47
2025	656,835.39	1,421,843.03	2,078,678.42	7,343,275.29	24,709.60	48,219.31	72,928.91	257,184.31	2,005,749.51	7,086,090.98
2026	798,532.37	1,383,611.34	2,182,143.71	9,525,419.00	30,040.12	46,922.75	76,962.87	334,147.18	2,105,180.83	9,191,271.82
2027	726,973.29	1,503,136.65	2,230,109.94	11,755,528.94	27,348.13	50,976.24	78,324.37	412,471.55	2,151,785.57	11,343,057.39
2028	620,429.62	1,545,341.96	2,165,771.58	13,921,300.52	23,340.04	52,407.56	75,747.61	488,219.16	2,090,023.98	13,433,081.37
2029	994,623.85	1,164,349.62	2,158,973.47	16,080,273.99	37,416.92	39,486.87	76,903.79	565,122.95	2,082,069.67	15,515,151.04
2030	1,967,443.16	154,071.33	2,121,514.49	18,201,788.48	74,013.57	5,225.06	79,238.63	644,361.58	2,042,275.86	17,557,426.90
2031	1,478,632.41	130,596.74	1,609,229.15	19,811,017.63	55,624.92	4,428.96	60,053.88	704,415.45	1,549,175.27	19,106,602.18
2032	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2033	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2034	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2035	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2036	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2037	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2038	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2039	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18

	Carbon stock changes in the below-ground biomass per initial forest class icl		Total carbon stock change in the below-ground biomass of the initial forest classes in the reference region		Carbon stock changes in below-ground biomass per post-deforestation zone z		Total carbon stock change in the below-ground biomass of post-deforestation zones in the reference region		Total net carbon stock change in the below-ground biomass of the reference region	
ID_{icl}	1	2	$\Delta Cbb\ BSLRR_{icl,t}$	$\Delta Cbb\ BSLRR_{icl,t}$	1	2	$\Delta Cbb\ BSLRR_{z,t}$	$\Delta Cbb\ BSLRR_{z,t}$	$\Delta Cbb\ BSLRR_{t}$	$\Delta Cbb\ BSLRR_{t}$
Name	As	Ds	annual	cummulative	As	Ds	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2040	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2041	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2042	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2043	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2044	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2045	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2046	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2047	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2048	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2049	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2050	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
2051	-	-	-	19,811,017.63	-	-	-	704,415.45	-	19,106,602.18
TOTAL	8,785,822.33	11,025,195.30	19,811,017.63		330,515.30	373,900.16	704,415.45		19,106,602.18	

Table 4.13. Final values of the total baseline carbon stock change for the above/belowground biomass pool in the project, leakage belt, and reference region for initial forest class at year t.

	Total net carbon stock change in the biomass of the project area		Total net carbon stock change in the biomass of the leakage belt area		Total net carbon stock change in the biomass of the reference region	
	$\Delta CBSLPA_t$	$\Delta CBSLPA$	$\Delta CBSLLK_t$	$\Delta CBSLLK$	$\Delta CBSLRR_t$	$\Delta CBSLRR$
	annual	cummulative	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2022	33,891.67	33,891.67	152,344.38	152,344.38	8,040,965.47	8,040,965.47
2023	517,815.41	551,707.08	242,379.30	394,723.69	8,852,112.34	16,893,077.81
2024	371,144.36	922,851.44	279,993.67	674,717.36	9,201,806.98	26,094,884.79
2025	235,318.32	1,158,169.75	615,531.15	1,290,248.51	10,302,265.04	36,397,149.83
2026	444,338.45	1,602,508.20	686,446.51	1,976,695.02	10,812,631.91	47,209,781.74
2027	614,550.02	2,217,058.22	198,540.42	2,175,235.43	11,052,288.47	58,262,070.21
2028	281,385.86	2,498,444.08	343,790.43	2,519,025.87	10,735,334.21	68,997,404.43
2029	837,049.45	3,335,493.53	410,226.15	2,929,252.02	10,693,273.48	79,690,677.91
2030	217,116.13	3,552,609.66	161,369.59	3,090,621.61	10,485,726.44	90,176,404.35
2031	274,756.83	3,827,366.49	428,961.41	3,519,583.02	7,954,027.36	98,130,431.71
2032	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2033	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2034	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2035	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2036	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2037	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2038	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2039	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2040	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71

	Total net carbon stock change in the biomass of the project area		Total net carbon stock change in the biomass of the leakage belt area		Total net carbon stock change in the biomass of the reference region	
	$\Delta CBSLPA_t$	$\Delta CBSLPA$	$\Delta CBSLLK_t$	$\Delta CBSLLK$	$\Delta CBSLRR_t$	$\Delta CBSLRR$
	annual	cummulative	annual	cummulative	annual	cummulative
Project year t	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e	tCO_2-e
2041	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2042	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2043	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2044	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2045	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2046	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2047	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2048	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2049	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2050	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
2051	-	3,827,366.49	-	3,519,583.02	-	98,130,431.71
TOTAL	3,827,366.49		3,519,583.02		98,130,431.71	

4.1.2 Baseline non-CO_2 emissions from forest fires[108]

In baseline calculations, it is crucial to understand the deforestation agent in the project area region. As reported previously, the Triunfo do Xingu conservation unit (Área de Proteção Ambiental - APA), located around the project area in the municipalities of São Félix do Xingu and Altamira, in Pará, was the Amazon conservation unit that burned the most in August 2020, with 49.60% of the total focus. In addition, São Félix do Xingu is the municipality with the largest cattle herd in Brazil, with almost 2.3 million head of cattle. In this case, the fires are used to clean and renew pastures, as well as to expand areas and open new pastures for cattle (INFOAMAZONIA, 2020). Thus, the deforestation agents usually use the fires to "clean the forest area" due to the logistical and legal difficulties of using tractors in the project area region. For this reason, the GHG estimation from biomass burning is considered in the baseline estimation. The conversion of forest to non-forest involving fires is a source of emissions of non-CO_2 gases (CH_4 and N_2O). To avoid double counting, the CO_2 emissions from forest fires have been disregarded because the impact of fire on carbon emissions is accounted for when estimating changes to carbon stocks.

To estimate non-CO_2 emissions from forest fires, it is necessary to calculate the average percentage of the deforested area, the average proportion of mass burnt in each carbon pool ($Pburnt_{p,icl}$), and the average combustion efficiency of each pool ($CE_{p,icl}$). In this case, 100% of the carbon is burnt in the deforestation area and this practice is made until 100% of combustion efficiency. These average percentage values are estimated for each forest class (icl) and are assumed to remain the same in the future. Based on the revised IPCC 1996 GL LULUCF, total GHG emission from biomass burning in forest class is estimated in Equation 5, Equation 6, and Equation 7.

$$\mathrm{EBBtot}_{\mathrm{icl,t}} = \mathrm{EBBN_2O}_{\mathrm{icl,t}} + \mathrm{EBBCH}_{4\ \mathrm{icl,t}}$$

Equation 5

$$\mathrm{EBBN_2O}_{\mathrm{icl,t}} = \mathrm{EBBCO}_{2\ \mathrm{icl,t}} \times \frac{12}{44} \times NCR \times ER_{N_2O} \times \frac{44}{28} \times GWP_{N_2O}$$

Equation 6

$$\mathrm{EBBCH}_{4\ \mathrm{icl,t}} = \mathrm{EBBCO}_{2\ \mathrm{icl,t}} \times \frac{12}{44} \times ER_{CH_4} \times \frac{44}{28} \times GWP_{CH_4}$$

Equation 7

$$\mathrm{EBBCO}_{2\ \mathrm{icl,t}} = Fburn_{icl} \times \sum_{p=1}^{P}(C_{p,icl,t} \times Pburnt_{p,icl} \times CE_{p,icl})$$

Where:

$\mathrm{EBBtot}_{\mathrm{icl,t}}$	Total GHG emission from biomass burning in forest class icl at year t; $tCO_2e.ha^{-1}$
$\mathrm{EBBN_2O}_{\mathrm{icl,t}}$	N_2O emission from biomass burning in forest class icl at year t, $tCO_2e.ha^{-1}$
$\mathrm{EBBCH}_{4\ \mathrm{icl,t}}$	CH_4 emission from biomass burning in forest class icl at year t, $tCO_2e.ha^{-1}$

[108] Annex: 230214_4_Calculation of Net GHG Emission Reductions and Removals_30 years.xlsx

$EBBCO_{2\ icl,t}$	Per hectare CO_2 emission from biomass burning in slash and burn in forest class icl at year t, $tCO_2e.ha^{-1}$
NCR	Nitrogen to Carbon Ratio); dimensionless NCR = 0.01 (page 3.50, IPCC (2006c))
ER_{N_2O}	Emission ratio for N_2O ER_{N_2O} = 0.007 (pg. 3.185, Table 3A.1.15, IPCC (2006a))
GWP_{N_2O}	Global Warming Potential for N_2O GWP_{N_2O} = 310 (pg. 22, Table 4, IPCC (1995))
ER_{CH_4}	Emission ratio for CH_4 ER_{CH_4} = 0.012 (pg. 3.185, Table 3A.1.15, IPCC (2006a))
GWP_{CH_4}	Global Warming Potential for CH_4 GWP_{CH_4} = 21 (pg. 22, Table 4, IPCC (1995))
$Fburn_{icl}$	Proportion of forest area burned during the historical reference period in the forest class icl; %
$C_{p,icl,t}$	Average carbon stock per hectare in the carbon pool p burnt in the forest class icl at year t; $tCO_2e.ha^{-1}$ $C_{p,icl,t}$ = 319.61 and 354.54 $tCO_2e.ha^{-1}$ for As and Ds vegetation type, respectively (Nogueira et al., 2015).
$Pburnt_{p,icl}$	Average proportion of mass burnt in the carbon pool p in the forest class icl; %
$CE_{p,icl}$	Average combustion efficiency of the carbon pool p in the forest class icl; dimensionless $CE_{p,icl}$ = 0.50 (Primary tropical moist forest) and 0.45 (Primary open tropical forest) (pg- 2.55, Table 2.6, IPCC (2006b))
p	Carbon pool that could burn (aboveground biomass, dead wood, litter)

The pasture carbon pool is also estimated because the unplanned deforestation in the project area occurs on land used for the pasture. For this calculation, the value of the 16.28 $tCO_2.ha^{-1}$ pasture is used (page 549, Table 1 (SILVA NETO et al., 2012)), considering that 100% of these deforested areas would be pasture (post-deforestation class). The baseline estimation is calculated considering the sum of the baseline emission and biomass burning minus the pasture carbon pool (Figure 4.3 and Table 4.14).

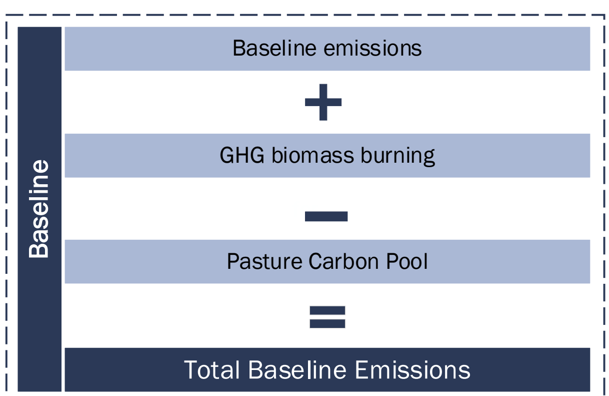


Figure 4.3. Schematic of total baseline emissions estimation

Table 4.14. The baseline estimation is calculated considering the sum of the baseline emission and biomass burning minus the pasture carbon pool

		Mass Burnt		Area Burnt		Avarage Carbon stok		Non-CO_2 emission		Biomass Burning Emissions (CH_4)		Biomass Burning Emissions (N_2O)		Biomass Burning Total		Pasture Carbon Pool		
	Vegetation type	As	Ds	As	Ds	As	Ds	As	Ds	As	Ds	As	Ds	All		All		Total BL-GHG
	Parameter	P_{burnt}		F_{burnt}		$C_{picl,t}$		$EBBCO_2$		$EBBCH_4$		$EBBN_2O$		EBBtot		E-Pasture Carbon Pool	E-Pasture Carbon pool Accumulative	
	Unit	%	%	%	%	$tCO_2e.ha^{-1}$		$tCO_2e.ha^{-1}$		$tCO_2e.ha^{-1}$		$tCO_2e.ha^{-1}$		$tCO_2e.ha^{-1}$	tCO_2e	tCO_2e	tCO_2e	
Period time (year)	2022	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	2,764.97	1,548.26	1,548.26	36,656.64
	2023	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	42,131.16	23,591.50	25,139.75	559,946.57
	2024	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	29,595.93	16,572.34	41,712.10	400,740.29
	2025	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	18,954.58	10,613.68	52,325.78	254,272.89
	2026	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	36,159.14	20,247.44	72,573.22	480,497.59
	2027	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	49,641.32	27,796.83	100,370.05	664,191.34
	2028	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	22,601.10	12,655.56	113,025.62	303,986.96
	2029	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	68,213.98	38,196.66	151,222.28	905,263.43
	2030	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	17,029.30	9,535.62	160,757.89	234,145.43
	2031	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	22,046.53	12,345.03	173,102.93	296,803.36
	2032	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2033	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2034	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2035	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2036	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2037	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2038	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2039	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2040	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2041	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2042	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2043	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2044	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2045	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2046	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2047	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2048	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2049	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2050	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	2051	100%	100%	100%	100%	300.44	333.27	136.52	151.44	12.51	13.88	1.27	1.41	29.07	-	-	173,102.93	-
	TOTAL															173,102.93		

4.2 Project Emissions

In the TdX project's project area, there is an absence of planned deforestation and wood management. In this case, the planned activities within the project area were not considered in the calculations. Nevertheless, some unplanned deforestation may happen in the project area despite the AUD project activity. The level at which deforestation will actually be reduced, in the project case, depends on the effectiveness of the proposed activities, which cannot be measured ex-ante. Ex-post measurements of the project results will be considered to determine actual emission reductions.

At this moment, the conservative approach considering the effectiveness of the proposed project activities was made, which estimates an Effectiveness Index (EI) between 0 (no effectiveness) and 1 (maximum effectiveness). The baseline predictions are multiplied by the factor $(1-El)$ using the estimated value of El, and the result is considered in the ex-ante estimated emissions from unplanned deforestation in the project case using the VM0015 approach (VERRA, 2012a). As previously reported, the project activities are (i) Identification of strategic points to establish surveillance checkpoints prioritizing zones bordering areas with high probability of invasion; (ii) establishment of surveillance checkpoints; (iii) establishment of the monthly frequency for the surveillance rounds; (iv) contact with neighboring communities in order to develop environmental education activities; (v) maintenance of "aceiros" or firebreak to fire protection; (vi) Identification of neighboring landowners in order to prevent leakage.

The project design team conservatively estimates that surveillance efforts can prevent unexpected deforestation inside the project area with an efficacy of 90%. As a result, Equation 8 was used to determine total ex-ante actual carbon stock change due to unavoided unplanned deforestation at year t in the project area ($\Delta\mathrm{CUDdPA}_t$).

$$\Delta\mathrm{CUDdPA}_t = \Delta\mathrm{CBSL}_t \times (1-El)$$

Equation 8

Where:

$\Delta\mathrm{CUDdPA}_t$	Total ex-ante actual carbon stock change due to unavoided unplanned deforestation at year t in the project area; tCO_2e
$\Delta\mathrm{CBSL}_t$	Total baseline carbon stock change at year t in the project area; tCO_2e
El	Ex-ante estimated Effectiveness Index; %
t	1, 2, 3 … T, a year of the proposed project crediting period; dimensionless

The total ex-ante actual non-CO_2 emissions from forest fire due to unavoidable unplanned deforestation at year t in the project area ($\mathrm{EBBPSPA}_t$) is estimated considering the efficacy of 90% (EI = 0.9) and the values of the total GHG emission from biomass burning in forest class icl at year t calculated in the baseline estimation (Equation 9).

$$EBBPSPA_t = EBBtot_t \times (1 - El)$$

Equation 9

Where:

$EBBPSPA_t$	Total ex-ante actual non-CO_2 emissions from forest fire due to unavoidable unplanned deforestation at year t in the project area; tCO_2e
$EBBtot_t$	Total GHG emission from biomass burning in forest class icl at year t; tCO_2e
El	Ex-ante estimated Effectiveness Index; %
t	1, 2, 3 … T, a year of the proposed project crediting period; dimensionless

Figure 4.4 depicts the estimated emissions for the project area. As previously described, the planned activities within the project area are null, so the total project area emission is equal to the estimation of the unplanned deforestation that cannot be avoided by adding the ex-ante estimation of actual non-CO_2 emissions from forest fires. Therefore, the total project emissions are represented in Table 4.15.

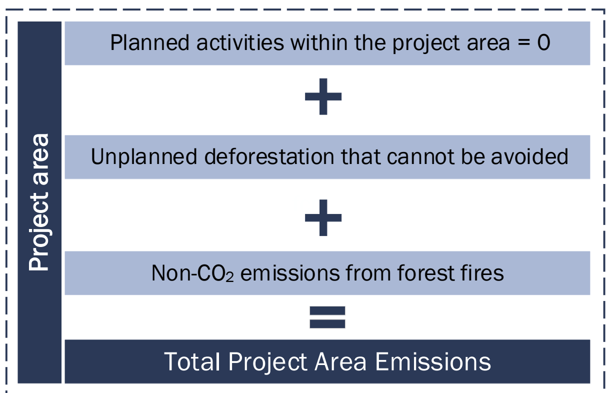


Figure 4.4. The total project area emissions estimation

Table 4.15. Total project emissions ex-ante estimation

			Baseline Emissions		Project emission - unplanned deforestation		Biomass Burning Total	Project emission - forest fires	Total PE
Parameter			ΔC_{BSLicl}	$\Delta C_{BSLicl\ accumulative}$	EI	ΔCCUDdPAt	EBBtot	EBBPSPAt	
Unit			tCO_2e	tCO_2e	%	tCO_2e	tCO_2e	tCO_2e	tCO_2e
Period time (year)	1st baseline period	2022	35,439.93	35,439.93	90%	3,543.99	2,764.97	276.50	**3,820.49**
		2023	541,406.90	576,846.83	90%	54,140.69	42,131.16	4,213.12	**58,353.81**
		2024	387,716.70	964,563.53	90%	38,771.67	29,595.93	2,959.59	**41,731.26**
		2025	245,932.00	1,210,495.53	90%	24,593.20	18,954.58	1,895.46	**26,488.66**
		2026	464,585.89	1,675,081.42	90%	46,458.59	36,159.14	3,615.91	**50,074.50**
		2027	642,346.85	2,317,428.27	90%	64,234.69	49,641.32	4,964.13	**69,198.82**
	2nd baseline period	2028	294,041.43	2,611,469.70	90%	29,404.14	22,601.10	2,260.11	**31,664.25**
		2029	875,246.11	3,486,715.81	90%	87,524.61	68,213.98	6,821.40	**94,346.01**
		2030	226,651.75	3,713,367.56	90%	22,665.17	17,029.30	1,702.93	**24,368.10**
		2031	287,101.86	4,000,469.42	90%	28,710.19	22,046.53	2,204.65	**30,914.84**
		2032	-	4,000,469.42	90%	-	-	-	-
		2033	-	4,000,469.42	90%	-	-	-	-
	3rd baseline period	2034	-	4,000,469.42	90%	-	-	-	-
		2035	-	4,000,469.42	90%	-	-	-	-
		2036	-	4,000,469.42	90%	-	-	-	-
		2037	-	4,000,469.42	90%	-	-	-	-
		2038	-	4,000,469.42	90%	-	-	-	-
		2039	-	4,000,469.42	90%	-	-	-	-
	4th baseline period	2040	-	4,000,469.42	90%	-	-	-	-
		2041	-	4,000,469.42	90%	-	-	-	-
		2042	-	4,000,469.42	90%	-	-	-	-
		2043	-	4,000,469.42	90%	-	-	-	-
		2044	-	4,000,469.42	90%	-	-	-	-
		2045	-	4,000,469.42	90%	-	-	-	-
	5th baseline period	2046	-	4,000,469.42	90%	-	-	-	-
		2047	-	4,000,469.42	90%	-	-	-	-
		2048	-	4,000,469.42	90%	-	-	-	-
		2049	-	4,000,469.42	90%	-	-	-	-
		2050	-	4,000,469.42	90%	-	-	-	-
		2051	-	4,000,469.42	90%	-	-	-	-
		TOTAL	4,000,469.42			400,046.94			430,960.74

4.3 Leakage

GHG emissions (other than carbon stock change) due to leakage.

Two sources of leakage are considered in this methodology and must be addressed:

- Decrease in carbon stocks and increase in GHG emissions associated with leakage prevention measures.
- Decrease in carbon stocks and increase in GHG emissions associated with activity displacement leakage.

4.3.1 Ex-ante estimation of the decrease in carbon stocks and increase in GHG emissions due to leakage prevention measures

Compared to the baseline case, carbon stocks may decrease, and/or GHG emissions may rise if leakage prevention efforts include tree planting, agricultural intensification, fertilization, fodder production, and/or other actions to improve cropland and grazing land areas. If the rise in GHG emissions or loss in carbon stock is considerable, it must be accounted for, and monitoring is necessary. Ex-post monitoring will not be required if it is not important and should not be accounted.

The following activities in leakage management areas could occasion a decrease in carbon stocks or an increase in GHG emissions:

- Carbon stock changes due to activities implemented in leakage management areas.
- Methane (CH_4) and nitrous oxide (N_2O) emissions from livestock intensification (involving a change in the animal diet and/or animal numbers).

This part of the computation does not apply in the context of this project activity. In the TdX project, the proactive measures to combat leakage sources will be: (i) identified neighbors in the leakage region to propose partnerships and passively avoid deforestation, (ii) supported by a collaborative effort with regional stakeholders to advance a new strategy for the region's land use and forestry, and (ii) mapping by satellite for monitoring interventions in the areas surrounding the project (the Leakage Belt). In this project, reducing carbon stocks from deforestation or increasing emissions from increased grazing operations are not part of leakage prevention activities. Therefore, the current project activity does not entail reducing carbon stocks or increasing GHG emissions linked to activities to avoid leakage.

4.3.2 Ex-ante estimation of the decrease in carbon stocks and increase in GHG emissions due to activity displacement leakage

Due to the execution of the AUD project activity, activities that would cause deforestation inside the project area in the baseline case may be relocated beyond the project boundary. If carbon stocks in the leakage belt area decrease more during project implementation than projected at baseline, this indicates that leakage has occurred due to displacement of baseline activities. Leakage due to activity displacement can thus be estimated by ex-post monitoring of deforestation in the leakage belt and comparing ex-post observed deforestation with ex-ante projected baseline deforestation.

However, ex-ante activity displacement leakage can only be guessed based on the anticipated combined effectiveness of the proposed leakage prevention measures and project activities. This shall be done by multiplying the estimated baseline carbon stock changes for the project area by a “Displacement Leakage Factor” (DLF) representing the percent of deforestation expected to be displaced outside the project boundary. As emissions from forest fires are included in the baseline, the ex-ante emissions from forest fires due to activity displacement leakage also be calculated by multiplying baseline forest fire emissions in the project area by the same DLF used to estimate the decrease in carbon stocks. Thus, the total decrease in carbon stock due to displaced deforestation and total GHG emission from biomass burning in the forest class is calculated using Equation 10 and Equation 11, respectively.

If deforestation agents do not participate in leakage prevention and project activities, the Displacement Factor shall be 100%. Where leakage prevention activities are implemented, the factor shall be equal to the proportion of the baseline agents estimated to be allowed to participate in leakage prevention activities and project activities. The project design team estimates that 100% of potential deforestation agents in the Reference Region will be given the opportunity to participate in leakage prevention activities. The TdX project's proactive measures to combat leakage sources include (i) identifying neighbors in the leakage region to propose partnerships and passively avoid deforestation; (ii) working in collaboration with regional stakeholders to advance a new strategy for the region's land use and forestry; and (iii) mapping by satellite for monitoring interventions in the areas around the project (the Leakage Belt). Thus, the “Displacement Leakage Factor” (DLF) was conservatively defined as 0.10.

$$\Delta \mathrm{CADLK}_t = \Delta \mathrm{CBSLPA}_t \times \mathrm{DLF}$$

Equation 10

$$\Delta \mathrm{EADLK}_t = \Delta \mathrm{EBBtot}_t \times \mathrm{DLF}$$

Equation 11

Where:

$\Delta \mathrm{CADLK}_t$	Total decrease in carbon stock due to displaced deforestation in the year t; tCO_2e
$\Delta \mathrm{CBSLPA}_t$	Total change in baseline carbon stock in the Project Area in year t; tCO_2e
DLF	Leakage displacement factor; %
$\Delta \mathrm{EADLK}_t$	Total GHG emission from biomass burning in forest class icl at year t; tCO_2e
$\Delta \mathrm{EBBtot}_t$	Total ex-ante estimated increase in GHG emissions due to displaced forest fires; tCO_2e

The leakage belt is equal to activity displacement leakage since the leakage as a result of preventative actions is null (Figure 4.5 and Table 4.16).

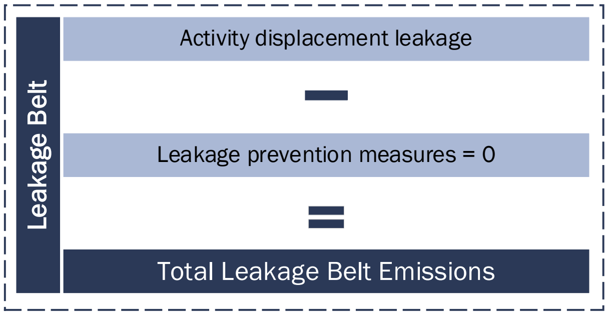


Figure 4.5. Leakage belt ex-ante estimation

Table 4.16. Ex ante estimation of the decrease in carbon stocks and increase in GHG emissions due to activity displacement leakage

		Baseline Emissions		Baseline Biomass Burning		Leakage					
Period time (year)	Parameter	$\Delta CBSLPAt$	$\Delta CBSLPAt$ cumulative	EBBtot	EBBtot cumulative	DLF	ΔCADLKt	ΔCADLKt cumulative	EADLKt	EADLKt cumulative	Total LK-GHG
	Unit	tCO_2e		tCO_2e		%	tCO_2e		tCO_2e		tCO_2e
1st baseline period	2022	35,439.93	35,439.93	2,764.97	2,764.97	10%	3,543.99	3,543.99	276.50	276.50	**3,820.49**
	2023	541,406.90	576,846.83	42,131.16	44,896.14	10%	54,140.69	57,684.68	4,213.12	4,489.61	**58,353.81**
	2024	387,716.70	964,563.53	29,595.93	74,492.06	10%	38,771.67	96,456.35	2,959.59	7,449.21	**41,731.26**
	2025	245,932.00	1,210,495.53	18,954.58	93,446.64	10%	24,593.20	121,049.55	1,895.46	9,344.66	**26,488.66**
	2026	464,585.89	1,675,081.42	36,159.14	129,605.77	10%	46,458.59	167,508.14	3,615.91	12,960.58	**50,074.50**
	2027	642,346.85	2,317,428.27	49,641.32	179,247.09	10%	64,234.69	231,742.83	4,964.13	17,924.71	**69,198.82**
2nd baseline period	2028	294,041.43	2,611,469.70	22,601.10	201,848.19	10%	29,404.14	261,146.97	2,260.11	20,184.82	**31,664.25**
	2029	875,246.11	3,486,715.81	68,213.98	270,062.17	10%	87,524.61	348,671.58	6,821.40	27,006.22	**94,346.01**
	2030	226,651.75	3,713,367.56	17,029.30	287,091.47	10%	22,665.17	371,336.76	1,702.93	28,709.15	**24,368.10**
	2031	287,101.86	4,000,469.42	22,046.53	309,138.00	10%	28,710.19	400,046.94	2,204.65	30,913.80	**30,914.84**
	2032	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2033	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
3rd baseline period	2034	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2035	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2036	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2037	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2038	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2039	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
4th baseline period	2040	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2041	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2042	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2043	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2044	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2045	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
5th baseline period	2046	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2047	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2048	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2049	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2050	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	2051	-	4,000,469.42	-	309,138.00	10%	-	400,046.94	-	30,913.80	-
	TOTAL	4,000,469.42		309,138.00			400,046.94		30,913.80		430,960.74

4.4 Net GHG Emission Reductions and Removals

The summary of the net GHG emission reductions or removals calculation is described in Figure 4.6.

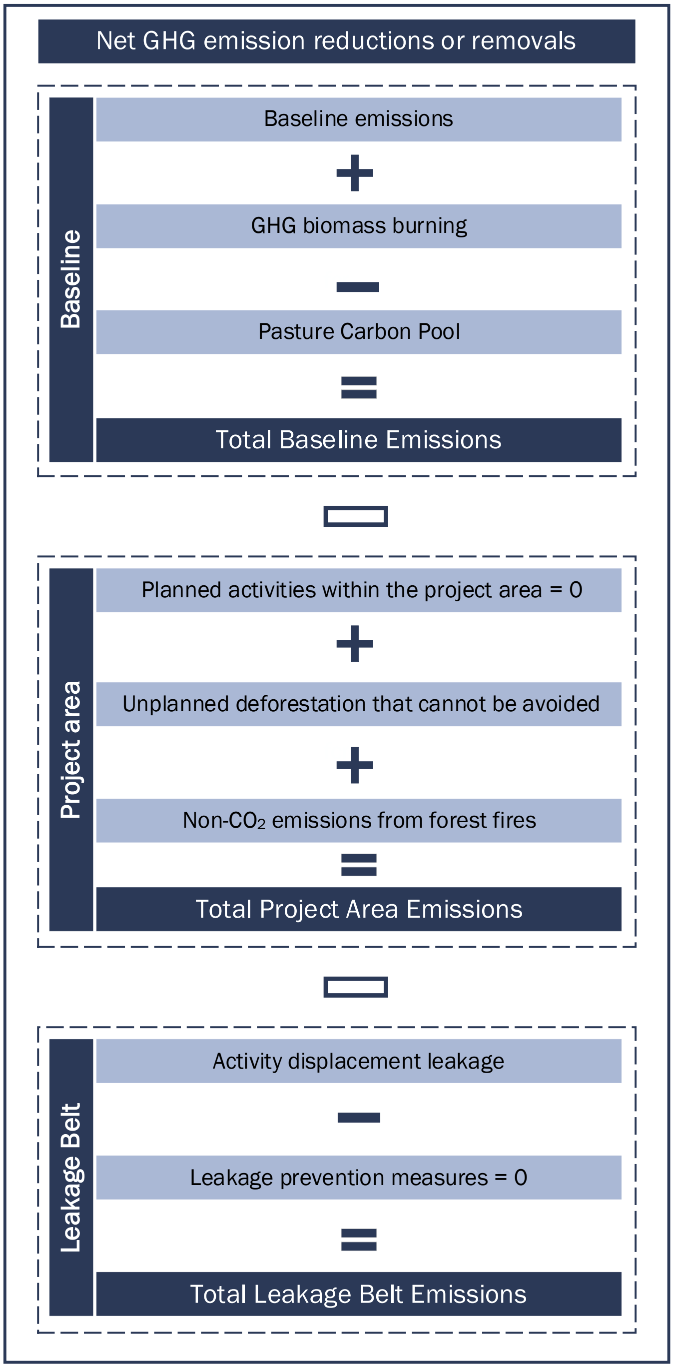


Figure 4.6. Summary of the calculation of Net GHG emission reductions or removals

It should be noted that the TdX project area is situated in Altamira municipality, which had the highest rate of deforestation in Brazil's Legal Amazon region by 2021 (G1, 2021). Furthermore, deforestation has increased in the last three years, with an average deforestation rate of over 71,277 ha year^{-1}

(TerraBrasilis, 2022). Deforestation in the reference region exhibits the linear adjustment at time function in accordance with VM0015 (VERRA, 2012a), as shown in Section 3.4. The aggressive deforestation rate causes the whole project area to be deforested until 2032, according to the modeling discussed in Section 3.4. Thus, the ABSLRR, -PA, and -LK estimated in this first analysis is zero from 2032 to 2033. This data demonstrates the critical significance of the RED initiative in this area. As a result, the quantification of GHG emission removals and reductions will be reported for an estimated 30 years in this Project Description: VCS Version document. In order to determine if this aggressive propensity will persist, the baseline estimation has to be reevaluated in the future.

The buffer pool allocation was estimated using the most recent version of the VCS-approved AFOLU Non-Permanence Risk Tool and the resulting value for the second baseline period was 10% (see Section 4 of the Non-Permanence Risk document). Hence, the estimated net GHG emission reductions or removals resulting from the difference between (i) the net GHG emission reductions or removals and (ii) buffer pool allocation (Table 4.17).

Table 4.17. Estimated net GHG emission reductions or removals

Year	Estimated baseline emissions or removals (tCO_2e)	Estimated project emissions or removals (tCO_2e)	Estimated leakage emissions (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)	Buffer pool allocation (tCO_2e)	VCUs eligible for Issuance (tCO_2e)
2022	36,656.64	3,820.49	3,820.49	29,015.66	2,901.57	26,114.10
2023	559,946.57	58,353.81	58,353.81	443,238.96	44,323.90	398,915.06
2024	400,740.29	41,731.26	41,731.26	317,277.76	31,727.78	285,549.98
2025	254,272.89	26,488.66	26,488.66	201,295.58	20,129.56	181,166.02
2026	480,497.59	50,074.50	50,074.50	380,348.58	38,034.86	342,313.73
2027	664,191.34	69,198.82	69,198.82	525,793.70	52,579.37	473,214.33
2028	303,986.96	31,664.25	31,664.25	240,658.45	24,065.85	216,592.61
2029	905,263.43	94,346.01	94,346.01	716,571.41	71,657.14	644,914.27
2030	234,145.43	24,368.10	24,368.10	185,409.22	18,540.92	166,868.30
2031	296,803.36	30,914.84	30,914.84	234,973.68	23,497.37	211,476.31
2032	-	-	-	-	-	-
2033	-	-	-	-	-	-
2034	-	-	-	-	-	-
2035	-	-	-	-	-	-
2036	-	-	-	-	-	-
2037	-	-	-	-	-	-
2038	-	-	-	-	-	-
2039	-	-	-	-	-	-
2040	-	-	-	-	-	-
2041	-	-	-	-	-	-
2042	-	-	-	-	-	-
2043	-	-	-	-	-	-
2044	-	-	-	-	-	-
2045	-	-	-	-	-	-
2046	-	-	-	-	-	-
2047	-	-	-	-	-	-
2048	-	-	-	-	-	-
2049	-	-	-	-	-	-
2050	-	-	-	-	-	-
2051	-	-	-	-	-	-
Total	**4,136,504.49**	**430,960.74**	**430,960.74**	**3,274,583.01**	**327,458.30**	**2,947,124.71**

5 MONITORING

5.1 Data and Parameters Available at Validation

Data and parameters available at validation are described below.

Data / Parameter	CF
Data unit	tC t d.m^{-1}
Description	Default value of carbon fraction in biomass
Source of data	VM0015 (VERRA, 2012a) and IPCC (2006d) page 4.49, Table 4.4
Value applied	0.47
Justification of choice of data or description of measurement methods and procedures applied	The default value was used for conservativeness purposes
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	If new and more accurate carbon fraction data become available, these can be used to estimate the net anthropogenic GHG emission reduction of the subsequent fixed baseline period.

Data / Parameter	Root-shoot ratio
Data unit	t root d.m.t^{-1} shoot d.m.
Description	Root to shoot ratio appropriate to species or forest type / biome; note that as defined here, root to shoot ratio is applied as belowground biomass per unit area: aboveground biomass per unit area (not on a per stem basis)
Source of data	VM0015 (VERRA, 2012a) and IPCC (2006d), page 4.48, Table 4.3
Value applied	Above-ground biomass <125 t/ha = 0.2 t root d.m.t^{-1} shoot d.m. Above-ground biomass >125 t/ha = 0.24 t root d.m.t^{-1} shoot d.m.
Justification of choice of data or description of	The IPCC and VM0015 factors are conservative values.

measurement methods and procedures applied	
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	Peer-reviewed work performed in the region of the Project Area, with a similar vegetation typology. The statistical quality of the model is in accordance with methodology requirements

Data / Parameter	44/12
Data unit	Dimensionless
Description	Ratio converting C to CO_{2e}
Source of data	VM0015 (VERRA, 2012a)
Value applied	44/12 = 3.67
Justification of choice of data or description of measurement methods and procedures applied	Carbon to carbon dioxide.
Purpose of Data	• Determination of baseline scenario • Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	Provide any additional comments
Data / Parameter	ab_{icl}
Data unit	$Mg.ha^{-1}$
Description	Average biomass stock per hectare in the above-ground biomass pool of initial forest class icl
Source of data	Nogueira et al. (2015)
Value applied	Open-canopy rainforest, submontane: 174.33 Dense-canopy rainforest, submontane: 193.39
Justification of choice of data or description of	A conservative approach through uncertainty assessment and the percentage of error was used. In this case, if the uncertainty of the

measurement methods and procedures applied	total average carbon stock is less than 10% of the average value, the average carbon stock value is used. Otherwise, the lower boundary of the 90% confidence interval is considered in the calculations. In this case, the conversion factor for a 90% confidence interval of 1.645 is used.
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	In the initial phase of the project, baseline values were based on vegetation type collected from geospatial data (IBGE, 2022a; Nogueira et al., 2015). This parameter will be updated when the TdX project biomass inventory is made in the project area. The Standard Operating Procedure (SOP)[109] document describes biomass inventory planning.

Data / Parameter	bb_{icl}
Data unit	$Mg.ha^{-1}$
Description	Average biomass stock per hectare in the below-ground biomass pool of initial forest class icl
Source of data	Nogueira et al. (2015)
Value applied	Open-canopy rainforest, submontane: 41.84 Dense-canopy rainforest, submontane: 46.41
Justification of choice of data or description of measurement methods and procedures applied	A conservative approach through uncertainty assessment and the percentage of error was used. In this case, if the uncertainty of the total average carbon stock is less than 10% of the average value, the average carbon stock value is used. Otherwise, the lower boundary of the 90% confidence interval is considered in the calculations. In this case, the conversion factor for a 90% confidence interval of 1.645 is used.
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	In the initial phase of the project, baseline values were based on vegetation type collected from geospatial data (IBGE, 2022a; Nogueira et al., 2015). This parameter will be updated when the TdX project biomass inventory is made in the project area. The

[109] Annex: 221014_SOP - Standard Operating Procedure.pdf

	Standard Operating Procedure (SOP)[110] document describes biomass inventory planning.

Data / Parameter	Cab_{icl}
Data unit	$tCO_2e.ha^{-1}$
Description	Average carbon stock per hectare in the above-ground biomass carbon pool of class icl
Source of data	Calculated
Value applied	Open-canopy rainforest, submontane: 300.44 Dense-canopy rainforest, submontane: 333.27
Justification of choice of data or description of measurement methods and procedures applied	$C_{ab_{icl}} = ab \times CF \times \frac{44}{12}$ These parameters are defined in this section.
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	In the initial phase of the project, baseline values were based on vegetation type collected from geospatial data (IBGE, 2022a; Nogueira et al., 2015). This parameter will be updated when the TdX project biomass inventory is made in the project area. The Standard Operating Procedure (SOP)[111] document describes biomass inventory planning.

Data / Parameter	Cbb_{icl}
Data unit	$tCO_2e.ha^{-1}$
Description	Average carbon stock per hectare in the below-ground biomass carbon pool of class icl
Source of data	Calculated
Value applied	Open-canopy rainforest, submontane: 72.10 Dense-canopy rainforest, submontane: 79.98

[110] Annex: 221014_SOP - Standard Operating Procedure.pdf

[111] Annex: 221014_SOP - Standard Operating Procedure.pdf

Justification of choice of data or description of measurement methods and procedures applied	$C_{bb_{icl}} = bb \times CF \times \frac{44}{12}$ These parameters are defined in this section.
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	In the initial phase of the project, baseline values were based on vegetation type collected from geospatial data (IBGE, 2022a; Nogueira et al., 2015). This parameter will be updated when the TdX project biomass inventory is made in the project area. The Standard Operating Procedure (SOP)[112] document describes biomass inventory planning.

Data / Parameter	$CE_{p,icl}$
Data unit	Dimensionless
Description	Average combustion efficiency of the carbon pool p in the forest class icl
Source of data	IPCC (2006b), Table 2.6, page 2.55
Value applied	Primary tropical moist forest: 0.50 Primary open tropical forest: 0.45
Justification of choice of data or description of measurement methods and procedures applied	The default value was used for conservativeness purposes.
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	N/A

Data / Parameter	NCR
Data unit	Dimensionless

[112] Annex: 221014_SOP - Standard Operating Procedure.pdf

Description	Nitrogen to Carbon Ratio
Source of data	VM0015 (VERRA, 2012a) and IPCC (2006c), page 3.50.
Value applied	0.01
Justification of choice of data or description of measurement methods and procedures applied	The default value was used for conservativeness purposes.
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	N/A

Data / Parameter	ER_{CH4}
Data unit	Dimensionless
Description	Emission ratio for CH_4
Source of data	VM0015 (VERRA, 2012a) and IPCC (2006a), page. 3.185, Table 3A.1.15.
Value applied	0.012
Justification of choice of data or description of measurement methods and procedures applied	The default value was used for conservativeness purposes.
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	N/A

Data / Parameter	ER_{NO2}
Data unit	Dimensionless
Description	Emission ratio for N_2O

Source of data	VM0015 (VERRA, 2012a) and IPCC (2006a), pg. 3.185, Table 3A.1.15.
Value applied	0.007
Justification of choice of data or description of measurement methods and procedures applied	The default value was used for conservativeness purposes.
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	N/A

Data / Parameter	GWP_{CH_4}
Data unit	tCO_2 $tgas^{-1}$
Description	Global Warming Potential for CH_4
Source of data	VM0015 (VERRA, 2012a) and IPCC (1995), pg. 22, Table 4.
Value applied	21
Justification of choice of data or description of measurement methods and procedures applied	The default value was used for conservativeness purposes.
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	N/A

Data / Parameter	GWP_{N_2O}
Data unit	tCO_2 $tgas^{-1}$
Description	Global Warming Potential for N_2O
Source of data	VM0015 (VERRA, 2012a) and IPCC (1995), pg. 22, Table 4.

Value applied	310
Justification of choice of data or description of measurement methods and procedures applied	The default value was used for conservativeness purposes.
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	N/A

Data / Parameter	$Pburnt_{p,icl}$
Data unit	%
Description	Average proportion of mass burnt in the carbon pool p in the forest class icl
Source of data	Local assessment
Value applied	100%
Justification of choice of data or description of measurement methods and procedures applied	*The project design team conservatively considers that surveillance activities are able to attain 90% of effectiveness in avoiding unplanned deforestation inside the Project Area.*
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	In baseline calculations, it is crucial to understand the deforestation agent in the project area region. As reported previously, the Triunfo do Xingu conservation unit (Área de Proteção Ambiental - APA), located around the project area in the municipalities of São Félix do Xingu and Altamira, in Pará, was the Amazon conservation unit that burned the most in August 2020, with 49.60% of the total focus. In addition, São Félix do Xingu is the municipality with the largest cattle herd in Brazil, with almost 2.3 million head of cattle. In this case, the fires are used to clean and renew pastures, as well as to expand areas and open new pastures for cattle (INFOAMAZONIA, 2020). Thus, the deforestation agents usually use the fires to "clean the forest area" due to the logistical and legal difficulties of using tractors in the project area region. In this case, 100% of the carbon is burnt in

	the deforestation area and this practice is made until 100% of combustion efficiency.

Data / Parameter	$Fburn_{icl}$
Data unit	%
Description	Proportion of forest area burned during the historical reference period in the forest class icl
Source of data	Local assessment
Value applied	100%
Justification of choice of data or description of measurement methods and procedures applied	*The project design team conservatively considers that surveillance activities are able to attain 90% of effectiveness in avoiding unplanned deforestation inside the Project Area.*
Purpose of Data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Comments	In baseline calculations, it is crucial to understand the deforestation agent in the project area region. As reported previously, the Triunfo do Xingu conservation unit (Área de Proteção Ambiental - APA), located around the project area in the municipalities of São Félix do Xingu and Altamira, in Pará, was the Amazon conservation unit that burned the most in August 2020, with 49.60% of the total focus. In addition, São Félix do Xingu is the municipality with the largest cattle herd in Brazil, with almost 2.3 million head of cattle. In this case, the fires are used to clean and renew pastures, as well as to expand areas and open new pastures for cattle (INFOAMAZONIA, 2020). Thus, the deforestation agents usually use the fires to "clean the forest area" due to the logistical and legal difficulties of using tractors in the project area region. In this case, 100% of the carbon is burnt in the deforestation area and this practice is made until 100% of combustion efficiency.

Data / Parameter	Pasture
Data unit	$tCO_2.ha^{-1}$
Description	Land used for the pasture
Source of data	(SILVA NETO et al., 2012)

Value applied	$(7.87 + 7.87 \times \text{Root shoot ratio}) \times \text{CF} \times 44/12$ = 16.28
Justification of choice of data or description of measurement methods and procedures applied	The pasture carbon pool is also estimated because the unplanned deforestation in the project area occurs on land used for the pasture.
Purpose of Data	• Calculation of baseline emissions
Comments	The default value was used for conservativeness purposes.

Data / Parameter	EI
Data unit	Dimensionless
Description	Ex ante estimated Effectiveness Index
Source of data	Local assessment
Value applied	0.9
Justification of choice of data or description of measurement methods and procedures applied	*The project design team conservatively considers that the project activities are able to attain 90% of effectiveness in avoiding unplanned deforestation inside the Project Area.*
Purpose of Data	• Calculation of project emissions
Comments	The project activities: a. Identification of strategic points to establish surveillance checkpoints prioritizing zones bordering areas with high probability of invasion; b. Establishment of surveillance checkpoints; c. Establishment of the monthly frequency for the surveillance rounds; d. Contact with neighboring communities in order to develop environmental education activities; e. Maintenance of "aceiros" or firebreak to fire protection; f. Identification of neighboring landowners in order to prevent leakage.

Data / Parameter	DLF
Data unit	Dimensionless

Description	Leakage displacement factor
Source of data	Local assessment
Value applied	0.1
Justification of choice of data or description of measurement methods and procedures applied	Justification of choice of data or description of measurement methods and procedures applied: If deforestation agents do not participate in leakage prevention activities and project activities, the Displacement Factor shall be 100%. Where leakage prevention activities are implemented, the factor shall be equal to the proportion of the baseline agents estimated to be given the opportunity to participate in leakage prevention activities and project activities. The project design team estimates that 100% of potential deforestation agents in the Reference Region will be given the opportunity to participate in leakage prevention activities. Thus, the "Displacement Leakage Factor" (DLF) was conservatively defined as 0.10.
Purpose of Data	• Calculation of leakage
Comments	In the TdX project, the proactive measures to combat leakage sources will be: (i) identified neighbors in the leakage region to propose partnerships and passively avoid deforestation, (ii) supported by a collaborative effort with regional stakeholders to advance a new strategy for the region's land use and forestry, and (ii) mapped by satellite for monitoring interventions in the areas surrounding the project (the Leakage Belt).

5.2 Data and Parameters Monitored

Data and parameters to be monitored in TdX are described in the tables below.

Data / Parameter	$ACPA_t$
Data unit	ha
Description	Annual area within the Project Area affected by catastrophic events at year t
Source of data	Remote sensing data and GIS and supervisor reports.
Description of measurement methods and procedures to be applied	The catastrophic events will be monitored using INMET (2022) and INPE (2022c) platform data and through periodic reports from area supervisor.
Frequency of monitoring/recording	Each time a catastrophic event occurs

Value applied	When significant, the value will be calculated ex-post each time a catastrophic event occurs.
Monitoring equipment	Remote sensing and GIS and supervisor reports.
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of project emissions
Calculation method	Analysis of satellite images and maps
Comments	N/A

Data / Parameter	$ABSLPA_{icl,t}$
Data unit	ha
Description	Area of initial forest class icl deforested at time t within the project area in the baseline case
Source of data	Remote sensing data and GIS.
Description of measurement methods and procedures to be applied	Forest cover change due to deforestation is monitored through periodic assessment of classified satellite imagery covering the project area.

Frequency of monitoring/recording	Annualy
Value applied	Annual average deforestation in the project area during the project crediting period
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of project emissions
Calculation method	Analysis of satellite images and maps
Comments	

Data / Parameter	$ABSLLK_{icl,t}$
Data unit	ha
Description	Area of initial (pre-deforestation) forest class icl deforested at time t within the leakage belt in the baseline case
Source of data	Remote sensing data and GIS.
Description of measurement methods	Deforestation in the leakage belt area will be considered activity displacement leakage. Activity data for the leakage belt area will

and procedures to be applied	be determined using the same methods applied to monitoring deforestation activity data in the project area.
Frequency of monitoring/recording	Annualy
Value applied	Values projected annually
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of leakage
Calculation method	Analysis of satellite images and maps
Comments	Where strong evidence can be collected that deforestation in the leakage belt is attributable to deforestation agents that are not linked to the project area, the detected deforestation will not be attributed to the project activity, thus not considered leakage.

Data / Parameter	$ABSRR_{icl,t}$
Data unit	ha
Description	Area of initial (pre-deforestation) forest class icl deforested at time t within the reference region in the baseline case

Source of data	Remote sensing data and GIS.
Description of measurement methods and procedures to be applied	The deforestation rate in the reference region is allocated by modelling in the project area (PA) and leakage area (LLK) to determine deforestation in the PA and LKK.
Frequency of monitoring/recording	Each baseline reassessment.
Value applied	Values projected annually
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of baseline emissions • Calculation of project emissions • Calculation of leakage
Calculation method	Analysis of satellite images and maps
Comments	N/A

Data / Parameter	$\Delta CADLK_t$
Data unit	tCO_2e

Description	Total decrease in carbon stock due to displaced deforestation in the year t
Source of data	Remote sensing data and GIS
Description of measurement methods and procedures to be applied	Deforestation in the leakage belt area will be considered activity displacement leakage. Activity data for the leakage belt area will be determined using the same methods applied to monitoring deforestation activity data in the project area.
Frequency of monitoring/recording	Annually
Value applied	Annual average decrease in carbon stocks due to displaced deforestation during the project crediting period
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of leakage
Calculation method	Calculation method: Emissions from deforestation are estimated by multiplying the detected area of forest loss by the average forest carbon stock per unit area.
Comments	N/A

Data / Parameter	$\Delta CPAdPA_t$
Data unit	tCO_2e
Description	Total decrease in carbon stock due to all planned activities at year t in the project area.
Source of data	Documents, remote sensing data and GIS
Description of measurement methods and procedures to be applied	The planned activities in the project area that result in carbon stock decrease will be subject to monitoring, when significant.
Frequency of monitoring/recording	Annually
Value applied	N/A
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of project emissions
Calculation method	Emissions from deforestation are estimated by multiplying the detected area of forest loss by the average forest carbon stock per unit area.
Comments	N/A

Data / Parameter	
Data unit	
Description	
Source of data	
Description of measurement methods and procedures to be applied	
Frequency of monitoring/recording	
Value applied	
Monitoring equipment	
QA/QC procedures to be applied	1)
Purpose of data	•
Calculation method	
Comments	

Data / Parameter	$\Delta CUDdPA_t$
Data unit	tCO_2e
Description	Total actual carbon stock change due to unavoided unplanned deforestation at year t in the project area
Source of data	Remote sensing data and GIS
Description of measurement methods and procedures to be applied	Forest cover change due to unplanned deforestation is monitored through periodic assessment of classified satellite imagery covering the project area.
Frequency of monitoring/recording	Annually
Value applied	Annual average decrease in carbon stocks due to unavoided unplanned deforestation during the project crediting period

Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of leakage
Calculation method	Emissions from deforestation are estimated by multiplying the detected area of forest loss by the average forest carbon stock per unit area.
Comments	N/A

Data / Parameter	$EBBPSPA_t$
Data unit	tCO_2e
Description	Sum of (or total) actual non-CO_2 emissions from forest fire at year t in the project area
Source of data	Supervisor reports, remote sensing data and GIS
Description of measurement methods and procedures to be applied	If forest fires occur, these non-CO_2 emissions will be subject to monitoring and accounting, when significant.

Frequency of monitoring/recording	Areas burnt will be monitored every 5 years or if verification occurs on a frequency of less than every 5 years, examination will occur prior to any verification event
Value applied	N/A
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of project emissions
Calculation method	Analysis of satellite images and maps to determine the incidence of deforestation and multiplying it by the respective emission factors.
Comments	If forest fires occur, these non-CO_2 emissions will be subject to monitoring and accounting.

Data / Parameter	$EADLK_t$
Data unit	tCO_2e
Description	Total increase in GHG emissions due to displaced forest fires at year t
Source of data	Remote sensing data and GIS

Description of measurement methods and procedures to be applied	When significant, GHG emissions due displaced forest fires will be monitored.
Frequency of monitoring/recording	Annually
Value applied	N/A
Monitoring equipment	Remote sensing and GIS
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of project emissions
Calculation method	Analysis of satellite images and maps to determine the incidence of deforestation and multiplying it by the respective emission factors.
Comments	Where strong evidence can be collected that forest fires in the leakage belt is attributable to deforestation agents that are not linked to the project area, the detected deforestation will not be attributed to the project activity, thus not considered leakage.

Data / Parameter	RF_t
Data unit	%

Description	Risk factor used to calculate VCS buffer creditst
Source of data	• VCS Non-Permanence Risk Report (v3.1), • Remote sensing data and GIS, • Supervisor report. • Literature data.
Description of measurement methods and procedures to be applied	All sources of data from the VCS Non-Permanence Risk Report will be used to measure the various risk factors
Frequency of monitoring/recording	Annually
Value applied	10
Monitoring equipment	VCS-approved AFOLU Non-Permanence Risk Tool
QA/QC procedures to be applied	Literature data from reputed sources will be used and critically checked. When possible, the average of two or more sources will be used.
Purpose of data	• Calculation of project emissions
Calculation method	All the risk factors described in the VCS Risk Report were assessed.
Comments	N/A

Data / Parameter	Deforestation in the project area and leakage belt
Data unit	ha
Description	Forest cover areas converted into non-forest areas inside the Project Area and Leakage Belt.
Source of data	Calculated through remote sensing images
Description of measurement methods and procedures to be applied	The monitoring of the forest cover in the Project Area and Leakage Belt will be done through satellite image analysis.
Frequency of monitoring/recording	Annually
Value applied	N/A

Monitoring equipment	Remote sensing images digital processing program, geographic information systems
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of project emissions • Calculation of leakage
Calculation method	Analysis of satellite images and maps
Comments	N/A

Data / Parameter	$\Delta CabBSLLK_t$
Data unit	tCO_2e
Description	Total carbon stock changes in the leakage belt area
Source of data	Calculated
Description of measurement methods and procedures to be applied	The TdX project's proactive measures to combat leakage sources include (i) identifying neighbors in the leakage region to propose partnerships and passively avoid deforestation; (ii) working in collaboration with regional stakeholders to advance a new strategy for the region's land use and forestry; and (iii) mapping by satellite for monitoring interventions in the areas around the project (the Leakage Belt).

Frequency of monitoring/recording	To be determined depending on the activity
Value applied	N/A
Monitoring equipment	Remote sensing images digital processing program, geographic information systems
QA/QC procedures to be applied	Best practices in remote sensing and GIS: 1) Land use and land cover mapping is assessed using Landsat satellites images with resolution 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine. 2) The Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022). 3) An independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used. 4) Conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020). 5) Also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019).
Purpose of data	• Calculation of leakage
Calculation method	Analysis of satellite images and maps to determine deforestation in Leakage Belt and multiplying it by the carbon stocks previously set.
Comments	N/A

Data / Parameter	A_{sp}
Data unit	ha
Description	Area of sample plots in biomass inventory
Source of data	Recording and archiving of number and size of sample plots.
Description of measurement methods and procedures to be applied	Cluster plot in Maltese cross setup with four rectangular sub-plots with 0,1 ha (10 m x 100 m) each.
Frequency of monitoring/recording	At least every ten years for forest biomass inventory renewal.
Value applied	0.4
Monitoring equipment	GPS and measuring tape.
QA/QC procedures to be applied	GPS coordinates are double checked in the field.
Purpose of data	• Calculation of baseline emissions
Calculation method	N/A
Comments	The biomass inventory will be estimated according to the Standard Operating Procedure (SOP)[113].

Data / Parameter	n
Data unit	Dimensionless
Description	Number of sample plots
Source of data	Recording and archiving of number of sample points.
Description of measurement methods and procedures to be applied	Calculated with statistic equation.
Frequency of monitoring/recording	At least every ten years for f*orest biomass inventory* renewal.
Value applied	55

[113] Annex: 221014_SOP - Standard Operating Procedure.pdf

Monitoring equipment	N/A.
QA/QC procedures to be applied	Standard statistic equation.
Purpose of data	• Calculation of baseline emissions
Calculation method	Calculated using the following formula: $$n = \frac{(t^2 \times CV^2)}{\left(E\%^2 + \left(\frac{t^2 \times CV^2}{N}\right)\right)}$$ Where: n Number of parcels sampled in each stratum (variable for each stratum) t Student t value at 90% of confidence level for (n-1) degree of freedom. CV Coefficient of variation (%) (variable for each stratum) $E\%$ Permissible sampling error (10%) N Number of parcels in total stratum area (variable for each stratum)
Comments	The biomass inventory will be estimated according to the Standard Operating Procedure (SOP)[114].

Data / Parameter	DBH
Data unit	cm
Description	Diameter at breast height of a tree in cm.
Source of data	Field measurements in sample plots.
Description of measurement methods and procedures to be applied	Measured 1.3m above ground. Measure all trees above some minimum DBH (≥ 10 cm) in the sample plots.
Frequency of monitoring/recording	Monitoring must occur at least every ten years for forest biomass inventory renewal. Where carbon stock enhancement is included, monitoring shall occur at least every five years.

[114] Annex: 221014_SOP - Standard Operating Procedure.pdf

Value applied	N/A
Monitoring equipment	Measuring tape.
QA/QC procedures to be applied	Standard quality control procedures for forest inventory including field data collection and data management were applied. The procedure of DBH measurement is already applied in national forest monitoring and is available from published handbooks, and from Penman et al. (2003) (an example of a handbook is MacDicken (1997)).
Purpose of data	• Calculation of baseline emissions
Calculation method	Diameter (DBH) is calculated based on circumference at breast height (CBH) measurement, by means of the basic perimeter equation: $$DBH = \frac{CBH}{\pi}$$
Comments	The biomass inventory will be estimated according to the Standard Operating Procedure (SOP)[115].

5.3 Monitoring Plan

The TdX-I1 Monitoring Plan was developed according to the approved VCS methodology VM0015 Methodology for Avoiding Unplanned Deforestation (AUD) v1.1, published on 03-December-2012. The methodology requires the fulfillment of three main monitoring tasks:

- Monitoring of actual carbon stock changes and GHG emissions within the project area;
- Monitoring of leakage; and
- Ex post calculation of net anthropogenic GHG emission reduction.

To prepare the Monitoring Plan, it is required by the methodology to describe how these tasks will be implemented, and for each task it must include the following sections:

- Technical description of the monitoring tasks.
- Data to be collected.
- Overview of data collection procedures.
- Quality control and quality assurance procedures.
- Data archiving.
- Organization and responsibilities of the parties involved in all the above.

[115] Annex: 221014_SOP - Standard Operating Procedure.pdf

The parties involved in monitoring activities are represented in Figure 5.1. The work between the project proponent and landowners' entities is very often interlinked and their smooth cooperation resulting in effective monitoring practices.

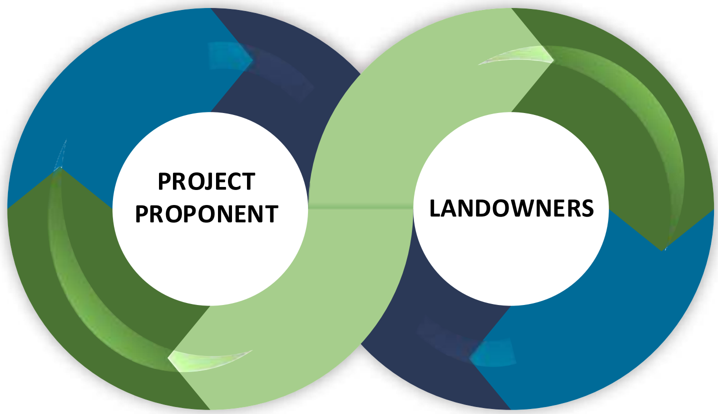
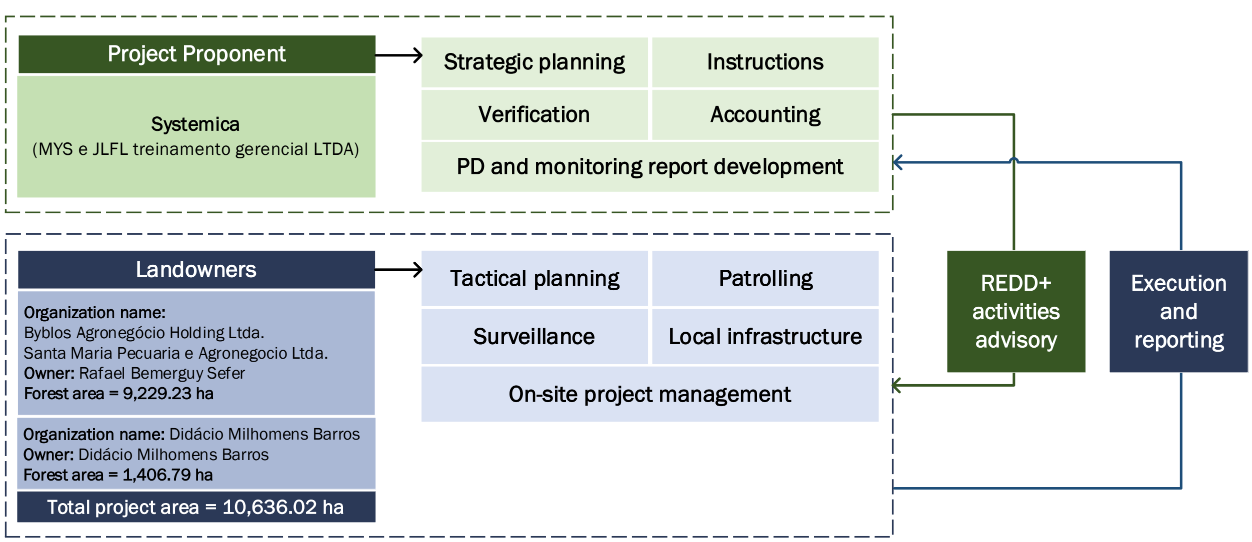


Figure 5.1. The parties involved in monitoring activities.

To clarify the general roles and responsibilities of the parties involved in the project seeks to describe each general role (Figure 5.2). The project proponent is responsible to the REDD+ activities advisor through strategic planning, verification, instructions, accounting and development of PD and monitoring report documents. General Systemica's quality control and quality assurance procedures are described in the "Sistema de Gestão de Qualidade Interna – Systemica"[116]. The landowners are responsible for the execution and reporting of information through tactical panning, patrolling, surveillance, local infrastructure, and on-site project management. Therefore, this structure involves the work collaboratively for monitoring activities.



[116] Annex: 221014_QA_QC_v00.pdf

Figure 5.2 General overview of parties involved in monitoring activities

5.3.1 Monitoring of actual carbon stock changes and GHG emissions within the project area

Technical description of the monitoring task.

Monitoring actual changes in carbon stock and GHG emissions within the Project Area involves four main scopes, which are: (i) monitoring of project implementation, (ii) monitoring of land use and land cover change, (iii) monitoring of carbon stocks and non-CO_2 emissions, and (iv) monitoring of impacts from natural disturbances and other catastrophic events. These tasks are described below:

- **Monitoring of project implementation:** Project activities implemented within the project area will be consistent with the management plans of the project area and the PD. All maps and records generated during the project implementation will be conserved and made available to VCS verifiers at verification for inspection to demonstrate that the AUD project activity has been implemented;
- **Monitoring of land-use and land-cover change:** The project area is not located in a region subjected to MRV by a jurisdictional program. Monitoring of LU/LC change within the project area will be performed annually by analyzing using images of the medium resolution, generated by MapBiomas. The large-scale monitoring will be done through satellite images made available by INPE (PRODES) and MapBiomas Alert data, which is a system that validates and refines deforestation alerts with high-resolution images;
- **Monitoring of carbon stocks and non-CO_2 emissions:** For carbon stocks, monitoring is mandatory within the project area for areas subject to unplanned and significant carbon stock decrease, e.g. due to uncontrolled forest fires and other catastrophic events. In these areas, carbon stock losses must be estimated as soon as possible after the catastrophic event. For non-CO2 emissions from forest fires, the TdX will proceed with monitoring and accounting when the event is significant, according to VM0015 (VERRA, 2012a);
- **Monitoring of impacts of natural disturbances and other catastrophic events:** Decreases in carbon stocks and increases in GHG emissions due to natural disturbances (e.g. in case of forest fires and other catastrophic events) or man-made events (such as acts of terrorism), including those over which the project proponent has no control, are subject to monitoring, when significant. If the area (or a subset of it) affected by natural disturbances or man-made events generated VCUs in past verifications, the total net change in carbon stocks and GHG emissions in the area(s) that generated VCUs will be estimated, and an equivalent amount of VCUs will be canceled from the VCS buffer. No VCUs can be issued for the project until all carbon stock losses and increases in GHG emissions have been offset.

Data to be collected.

It is important to emphasize here the best practices in remote sensing and GIS to obtain consistent data using the conservative approach: (i) land use and land cover mapping is assessed using Landsat satellite images with resolution of 30 meters (MapBiomas, 2022) validating through a pixel-by-pixel based machine learning algorithms classification using Google Earth Engine; (ii) the Mapbiomas methodology uses image with minimal cloud cover product of Landsat scenes mosaicked from various months of the year (MapBiomas, 2022); (iii) an independent verifiable accuracy assessment was performed using high-resolution image with 5 m resolution from Planet Image to confirm the minimum map accuracy of 90% for each land use class used; (iv) conservatively the secondary forest is eliminated of the forest class according to Silva Junior et al. (2020); (v) also, with the objective of reducing the classification error between forest cover maps, a PRODES hydrography mask was downloaded by TerraBrasilis plataform is added in each forest cover maps map, in this way, this land use class remained unchanged in all years (Assis et al., 2019). The data collection is covered below:

- **Monitoring of project implementation** will be performed by the monitoring of deforestation-avoidance activities through evaluations of the surveillance rounds and continuous monitoring activities with advanced remote sensing techniques and satellite images analysis. Social consultation data and signed attendance list are and will be collected while the community engagement occurs and will be made available to VCS verifiers.
- **Monitoring of land-use and land-cover change within the project area** will be subject to MRV-A (monitoring, reporting, verification and accounting) to the "Area of forest land converted to non-forest land" (mandatory for this AUD project) and the "Area of forest land undergoing carbon stock increase" if the carbon stock increase is significant according to ex-ante assessment and will be only accounted on areas that will be deforested in the baseline case.

According to Methodology VM0015 (VERRA, 2012a), the results of monitoring will be reported by creating ex-post tables of activity data according to describe in Table 5.1.

Table 5.1. Parameters reported for ex-post monitoring analysis

Data/ Parameter	Description	Unit	Source	Frequency
$ABSLRR_{icl,t}$	Annual areas of baseline deforestation in the reference region per stratum i (VM0015, Table 9), per forest class icl (VM0015, Table 11) and per post-deforestation zone z (VM0015, Table 13).	ha	Remote sensing data and GIS.	Annual
$ABSLPA_{icl,t}$	Annual areas of baseline deforestation in the project area per stratum i (VM0015, Table 9), per forest class icl (VM0015, Table 11) and per post-deforestation zone z (VM0015, Table 13).	ha	Remote sensing data and GIS.	Annual
$ABSLLK_{icl,t}$	Annual areas of baseline deforestation in the leakage belt per stratum i (VM0015, Table 9), per forest class icl (VM0015, Table 11) and per post-deforestation zone z (VM0015, Table 13).	ha	Remote sensing data and GIS.	Annual
$\Delta CUDdPA_t$	Total change in actual carbon stock due to unavoidable unplanned deforestation in year t in the Project Area	tCO_2	Calculated using the detected areas of forest loss in the Project Area and average carbon stock	Annual

Data/ Parameter	Description	Unit	Source	Frequency
$AUFPA_{icl,t}$	Areas affected by forest fires in the icl class in which carbon stock recovery occurs in year t	ha	Proper sources for forest fire detection and the scars caused to identify and classify affected areas	Whenever forest fires occur
$\Delta CUFdPA_t$	The total reduction in carbon stock due to unplanned (and planned - where applicable) forest fires in year t in the Project Area	tCO_2	Calculated using the affected areas in the Project Area and the average carbon stock	Whenever forest fires occur
$ACPA_{icl,t}$	Analysis Area within the Project Area affected by catastrophic events in class icl in year t	ha	Remote sensing data and GIS.	Whenever a catastrophic event occurs
$\Delta CUCdPA_t$	The total reduction in carbon stock due to catastrophic events in year t in the Project Area	tCO_2	Calculated using the affected areas in the Project Area and the average carbon stock	Whenever a catastrophic event occurs

Monitoring of carbon stock changes and non-CO_2 emissions from forest fires: An estimation of carbon stocks using Forest Inventory data within the project area will be performed to generate more accurate carbon stock values, which will be made available to VCS verifiers at verification for inspection. The field inventory methodology and data to be collected are described in a Standard Operating Procedure (SOP)[117], which is available for consultation by the auditors. The results of monitoring activity data and carbon stocks will be reported using the same formats and tables used for the ex-ante assessment, according to Methodology VM0015 (VERRA, 2012a) (the applicability of each table must be evaluated ex-post, in the Monitoring Report) according to Table 5.2.

Table 5.2. The results of monitoring activity data and carbon stocks must be reported using the same formats and tables used in VM0015 (VERRA, 2012a) for ex-ante assessment.

Description of parameter	VM0015 (VERRA, 2012a)
Ex post carbon stock per hectare of initial forest classes icl existing in the project area and leakage belt	Table 15
Ex post carbon stock per hectare of final classes fcl existing in the project area and leakage belt	Table 16
Ex post carbon stock decrease due to planned and unplanned deforestation in the project area.	Table 25.a
Ex post carbon stock decrease due to planned logging activities.	Table 25.b

[117] Annex: 221014_SOP - Standard Operating Procedure.pdf

Description of parameter	VM0015 (VERRA, 2012a)
Ex post carbon stock decrease due to planned fuel-wood and charcoal activities	Table 25.c
Total ex-post carbon stock decrease due to planned activities in the project area.	Table 25.d
Ex post carbon stock decrease due to forest fires.	Table 25.e
Ex post carbon stock decrease due to catastrophic events	Table 25.f
Total ex-post carbon stock decrease due to forest fires and catastrophic events	Table 25.g
Ex post carbon stock increase due to growth without harvest	Table 26.a
Ex post carbon stock increase following planned logging activities	Table 26.b
Ex post carbon stock increase following planned fuel-wood and charcoal activities	Table 26.c
Total ex-post carbon stock increase due to planned activities in the project area	Table 26.d
Ex post carbon stock increase on areas affected by forest fires.	Table 26.e
Ex post carbon stock increase in areas affected by catastrophic events.	Table 26.f
Ex post carbon stock increase on areas recovering after forest fires and catastrophic events.	Table 26.g
Ex post total net carbon stock change in the project area.	Table 27

Non-CO2 emissions from forest fires will be subject to monitoring and accounting, when significant. In this case, under the project scenario, it will be necessary to monitor the variables of Table 23 within the project area and to report the results in Table 24, according to VM0015 (VERRA, 2012a).

Monitoring of impacts of natural disturbances and other catastrophic events: Decreases in carbon stocks and increases in GHG emissions (e.g., in case of forest fires) due to natural disturbances (such as hurricanes, earthquakes, volcanic eruptions, tsunamis, flooding, drought, fires, tornados or winter storms) or man-made events, including those over which the project proponent has no control (such as acts of terrorism or war), are subject to monitoring and must be accounted under the project scenario, when significant. TdX will use tables 25.e, 25.f and 25.g to report carbon stock decreases and, optionally, tables 26.e, 26.f and 26.g to report carbon stock increases that may happen on the disturbed lands after the occurrence of an event. The catastrophic events will be monitored using INMET (2022) and INPE (2022c) platform data and through periodic reports from the area supervisor.

If the area (or a subset of it) is affected by natural disturbances or man-made events that generated VCUs in past verifications, the total net change in carbon stocks and GHG emissions in the area(s) that generated VCUs will be estimated, and an equivalent amount of VCUs will be canceled from the VCS buffer.

The results of all ex-post estimations will be summarized in the project area using the same table format used for the ex-ante assessment: Table 29 of VM0015 (VERRA, 2012a) describes the total ex-post estimated actual net changes in carbon stocks and emissions of GHG gases in the project area.

Overview of data collection procedures.

General remote monitoring will be done with remote sensing methods, using images of medium resolution. The large-scale monitoring will be done through satellite images made available by INPE (PRODES) and MapBiomas Alert data, which is a system that validates and refines deforestation alerts with high-resolution images by integrating and analyzing multiple alert systems, such as DETER, PRODES and so on. This platform data is widely used because it integrates and validates the alerts of several products increasing the reliability of the data and can be acquired on a daily frequency.

The forest condition within the Project Area and forest cover change due to unplanned deforestation are monitored through periodic assessment of classified satellite imagery covering the project area and is subject to monitoring the conversion of forest land to non-forest land. While increase or decrease in carbon stocks due to planned activities in the project area will also be monitored through documents and the data to be collected consists of annual satellite imagery processed by PRODES, for the entire land coverage of the Project Area.

The surveillance and patrolling will be implemented and established by the project landowners to work as monitoring at the farms, as a strategy for looking after the property and assure avoided entry of outsiders, hunters, fishermen and intrusion, the prevention of invasion, fire prevention, support the work of the field inventory, cleaning of frontiers and its milestones and internal organization of communication.

Monitoring of social parameters of project implementation will be based on local community consultation and mapping the community needs, which attest that foreseen activities are being effectively implemented, and documentation related to activity implementation, as well as signed attendance lists.

Monitoring of carbon stock changes and non-CO2 emissions from forest fires of areas subject to significant carbon stock decrease in the project scenario according to the ex-ante assessment, the carbon stock changes will be estimated, in case of planned deforestation, at least once after each harvest event. In case areas are subject to unplanned and significant carbon stock decrease, e.g., due to uncontrolled forest fires and other catastrophic events, in these areas, carbon stock losses will be estimated as soon as possible after the catastrophic event.

The forest inventory methodology described in the SOP was specifically designed for TdX carbon inventories, to be applied in the baseline assessment, as well as in the monitoring period. The field carbon inventory involved the installation of 55 permanent cluster plots (Figure 5.3). These permanent plots will be periodically assessed throughout the project duration.

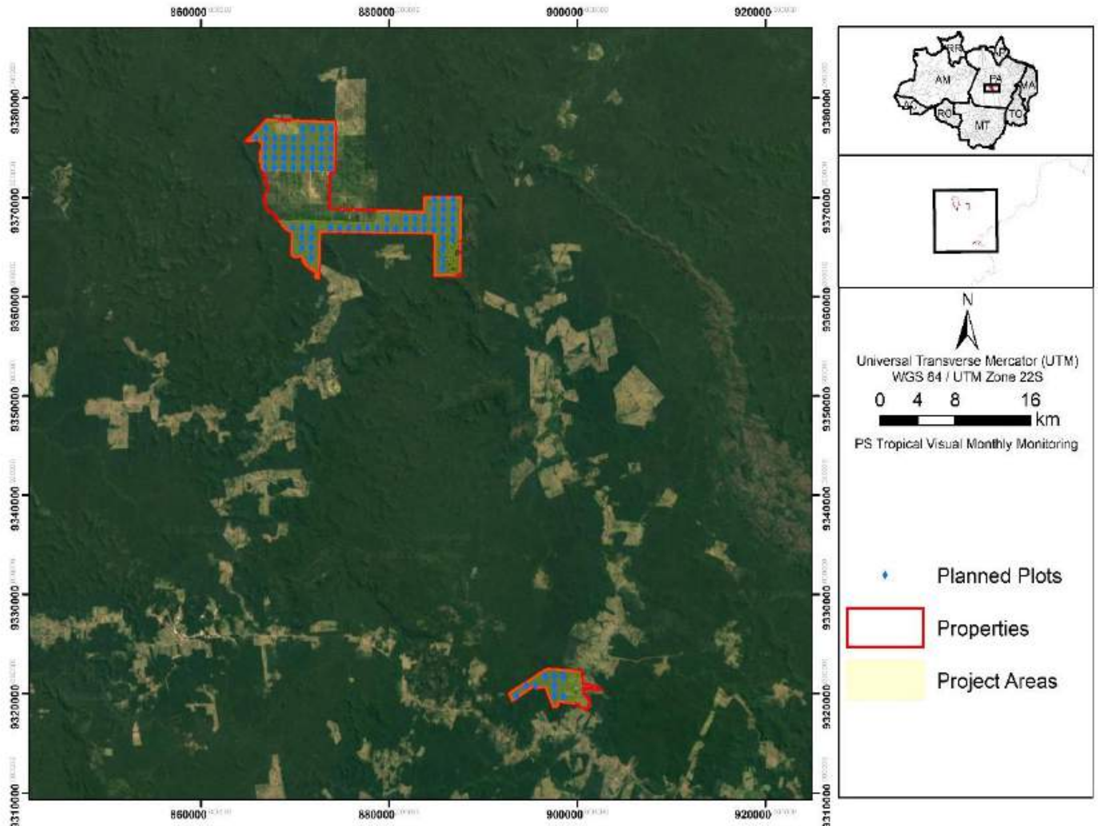


Figure 5.3 TdX Forest Biomass Inventory Permanent Cluster Plots

The field inventory SOP (available for consultation by the auditors) describes the guidelines for the following aspects:

- Sampling method and sampling process;
- Procedures for allocation of plots in the field;
- Variables to be collect in forest inventory
- Standards for measurement of tree diameters under several conditions;
- Rules to process the borderline trees
- Documentation of coordinates of plots;
- Standards for identification and signalization of plots;
- Description of forest inventory team;
- Standards for measurement dynamics of the field inventory team;
- QA/QC procedures to guarantee the application of correct field procedures(annual training, evaluation, and performance reporting);
- Items for annual evaluation of field inventory team;

- QA/QC procedures to guarantee that field data are within the range of treedimensions required in the field inventory;
- QA/QC procedures to guarantee that there was no misunderstanding in datanotation in the field;
- QA/QC procedures to guarantee the reliability of data transfer;
- Model of data transfer error quantification and report;
- List of equipment and materials to be used in the field inventory.

Quality control and quality assurance procedures.

The validation of land-use data used for modeling of land use will be performed by using the confusion matrix, in order to calculate the overall index of success by period and by class. Three specific classes will be used: forest, deforestation and non-forest (hydrography, not forest, clouds, roads, residues, unclassified objects, and others). The validation will be performed by using the land use mapping PRODES Digital, and the satellite images used will be scenes of satellite Landsat 8 TM to the total geographic scope of the Project Area and Reference Region. With the help of the "Create Random Points" tool in ArcGIS 10.0, 100 random points will be generated for each class / year as samples for evaluation, using satellite images as reference, making it possible to generate a confusion matrix for calculation of the accuracy indexes, and the Kappa index (indicators for validation of mapping accuracy). Land use classes must have higher values than 90% accuracy for the accuracy and Kappa index, as required in VM00015 1.1.3 methodology (VERRA, 2012a).

Data archiving.

All images, maps and records generated during project implementation should be conserved and made available to VCS verifiers at verification for inspection to demonstrate that the AUD project activity has actually been implemented.

After the annual evaluation of the field inventory team, the team coordinator must produce an annual Evaluation Report for each field inventory technician. This Evaluation Report will be printed in two hardcopies: one for TdX records and other for the field inventory technician that was evaluated. This document will be the evidence of the annual evaluation of the field inventory team.

Organization and responsibilities of the parties involved in all the above.

The Systemica LTDA. is responsible for generating the maps, GIS analysis, remote monitoring of the project area, data archiving, and for providing assistance and clarification during verification audits.

The landowner will be responsible for implementing the patrolling and surveillance system and providing the necessary vehicles and infrastructure if relevant to develop the project activities, as well as being co-responsible for data archiving.

Field team inventory is responsible for providing all the required information for Systemica during the forest inventory, as well as being co-responsible for data archiving.

5.3.2 Monitoring of leakage

The TdX project area is not located within a jurisdiction that is monitoring, reporting, verifying and accounting for GHG emissions from deforestation under a VCS or UNFCCC registered program. Furthermore, as the leakage belt was determined using Option 1 (Opportunity cost analysis), the boundary of the leakage belt will have to be reassessed at the end of each fixed baseline period using the same methodological approaches used in the first period.

Technical description of the monitoring tasks.

According to the VM0015 methodology (VERRA, 2012a), the sources of leakage identified as significant in the ex-ante assessment are subject to monitoring. Two sources of leakage are potentially subject to monitoring:

- Decrease in carbon stocks and increase in GHG emissions associated with leakage prevention activities;
- Decrease in carbon stocks and increase in GHG emissions due to activity displacement leakage.

This Project Activity does not involve a decrease in carbon stocks and an increase in GHG emissions associated with leakage prevention activities, only the decrease in carbon stocks and increase in GHG emissions due to activity displacement leakage will be monitored.

Data to be collected.

Deforestation above the baseline in the leakage belt area will be considered activity displacement leakage with the parameters presented in Table 5.3.

Table 5.3. Data to be collected for monitoring changes in carbon stock and GHG emissions for

Data/ Parameter	Description	Unit	Source	Frequency
$\Delta CLPMLK_t$	Decrease of carbon stocks due to prevention measures in the leakage belt in year t.	tCO_2e	Follow-up report of project activities that were implemented and other records related to the leakage prevention activities	Whenever the event occurs
EgLKt	Emissions from grazing animals in the Leakage Belt areas in year t	tCO_2e	Existing records on the practice of grazing	Whenever the event occurs
$ABSLLK_t$	Annual areas of baseline deforestation in the leakage belt in year t	ha	Remote sensing data and GIS.	Annual
$\Delta CADLK_t$	Total decrease of carbon stocks displaced due to deforestation in year t	tCO_2e	Calculated using the detected areas of forest loss in the Leakage Belt, the weighted average carbon stock, and the estimated loss in carbon stock at baseline for the Leakage Belt	Annual

The result of the ex-post estimations of carbon stock changes must be reported using the same table formats used in the ex-ante assessment of baseline carbon stock changes in the leakage belt (Table 5.4).

Table 5.4. Ex-post estimations parameters of carbon stock changes

Description of parameter	VM0015 (VERRA, 2012a)
Ex post above-ground net carbon stock changes in the leakage belt.	Table 22.c.1
Ex post below-ground net carbon stock changes in the leakage belt.	Table 22.c.2
Ex post net carbon stock changes in the wood products in the leakage belt.	Table 25.c.6

To estimate the increased GHG emissions due to forest fires in the leakage belt area the assumption is made that forest clearing is done by burning the forest. The parameter values used to estimate emissions shall be the same used for estimating forest fires in the baseline (table 23), except for the initial carbon stocks (Cab, Cdw) which shall be those of the initial forest classes burned in the leakage belt area. Where strong evidence can be collected that forest fires in the leakage belt is attributable to deforestation agents that are not linked to the project area, the detected deforestation will not be attributed to the project activity, thus not considered leakage.

Report the result of the estimations using the same table formats used in the ex-ante assessment of baseline GHG emissions from forest fires in the project area:

Table 5.5.Ex-ante assessment of baseline GHG emissions parameters from forest fires in the project area

Description of parameter	VM0015 (VERRA, 2012a)
Parameters used to calculate emissions from forest fires in the leakage belt area.	Table 23
Ex post estimated non-CO_2 emissions from forest fires in the leakage belt area.	Table 24

The results of all ex-post estimations of leakage are summarized using the same table format used for the ex-ante assessment represented by Table 35. Total ex-post estimated leakage in VM0015 (VERRA, 2012a).

Overview of data collection procedures.

The carbon stock decrease due to leakage prevention measures, which will probably take place inside the leakage management area, will be monitored through documents and field assessment.

In areas undergoing carbon stock enhancement, the project conservatively assumes stable stocks and no biomass monitoring is conducted.

Deforestation in the leakage belt area may be considered activity displacement leakage. Activity data for the leakage belt area will be determined using the same methods applied to monitoring deforestation activity data in the project area. Furthermore, GHG emissions from displaced forest fires within the leakage belt will also be accounted for, if significant.

Leakage will be calculated by comparing ex-ante and ex-post evaluation. However, it is worth noting that where there is strong evidence can be collected that deforestation in the leakage belt is attributable to agents of deforestation that are not linked to the project area, the detected deforestation will not be attributed to the project activity, therefore, no will be considered leakage.

Quality control and quality assurance procedures.

The validation of land-use data used for modeling land use will be performed by using the confusion matrix, to calculate the overall index of success by period and by class. Three specific classes will be used: forest, deforestation, and non-forest (hydrography, not forest, clouds, roads, residues, unclassified objects, and others). The validation will be performed by using the land use mapping PRODES Digital, and the satellite images used will be scenes of satellite Landsat 8 TM to the total geographic scope of the Project Area and Reference Region. With the help of the "Create Random Points" tool in ArcGIS 10.0, 100 random points will be generated for each class/year as samples for evaluation, using satellite images as reference, making it possible to generate a confusion matrix for calculation of the accuracy indexes, and the Kappa index (indicators for validation of mapping accuracy). Land use classes must have higher values than 90% accuracy for the accuracy and Kappa index, as required in VM00015 1.1.3 methodology (VERRA, 2012a).

Data archiving.

All images, maps and records generated during project implementation should be conserved and made available to VCS verifiers at verification for inspection to demonstrate that the AUD project activity has been implemented.

Organization and responsibilities of the parties involved in all the above.

The Systemica LTDA. is responsible for generating the maps, GIS analysis and remote monitoring of the project area, data archiving, and for providing assistance and clarification during verification audits.

5.3.3 Ex post calculation of net anthropogenic GHG emission reduction

Technical description of the monitoring tasks.

If new and more accurate carbon stock data become available, these can be used to estimate the net anthropogenic GHG emission reduction, provided that these data are in accordance with the requirements established by the applied methodology VM0015 (VERRA, 2012a). The calculation of ex-post net anthropogenic GHG emission reductions is similar to the ex-ante calculation.

Data to be collected.

The report of ex-post estimated net anthropogenic GHG emissions and calculation of Verified Carbon Units will apply the same table format used for the ex-ante assessment, according to VM0015 (VERRA, 2012a): Table 36: Ex post estimated net anthropogenic GHG emission reductions and VCUs.

Overview of data collection procedures.

The data collection procedures involve the compilation of data from previous procedures to calculate ex-post net anthropogenic GHG emission reduction.

Quality control and quality assurance procedures.

All the previous relevant QC/QA procedures are applicable for the ex-post calculation of net anthropogenic GHG emission reduction. The cumulative areas credited map within the project area shall be updated and presented to VCS verifiers at each verification event. The cumulative area cannot generate additional VCUs in future periods.

Data archiving.

All maps and records generated during the project implementation will be conserved and made available to VCS verifiers at verification for inspection to demonstrate that the AUD project activity has been implemented. The procedures meet the highest levels of control, and the main purpose is to minimize the risk of error, obtaining reliable data on which to base the monitoring results, and thus, minimizing non-conformities (Table 5.6). If non-conformities exist during the internal or external auditing processes, the data should be reviewed, and the non-conformities addressed.

Table 5.6. Data to be collected for monitoring changes in carbon stock and GHG emissions for

Data/ Parameter	Description	Unit	Source	Frequency
RF_t	Risk factor used to calculate the VCS buffer	%	VCS Non-Permanence Risk Report	Annually

Organization and responsibilities of the parties involved in all the above.

Systemica is responsible for calculating and reporting the ex-post estimated net anthropogenic GHG emissions, data archiving, and for providing assistance and clarification during verification audits.

5.3.4 Revisiting the baseline projections for future fixed baseline period

The Systemica LTDA. is responsible for revisiting the baseline projections for a fixed baseline period. The current baseline is valid for 6 years, i.e. through August 2028. The baseline will be reassessed every 6 years, and it will be validated at the same time as the subsequent verification.

Updating information on agents, drivers and underlying causes of deforestation in the reference region will be collected at the end of each fixed baseline period, as these are essential for improving future deforestation projections and the design of the project activity. In addition, the projected annual areas of baseline deforestation for the reference region will be revisited and recalibrated in the model for projection of future deforestation, using new "Factor Maps" eventually adjusted for the subsequent fixed baseline period.

Adjusting the land-use and land-cover change component of the baseline involves reassessing components of the baseline projections, such as the adjustment of annual areas and the location of baseline deforestation. Updating of the Carbon component of the baseline will only be carried out if more accurate methods for carbon stock estimates are available on the occasion of baseline revision.

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